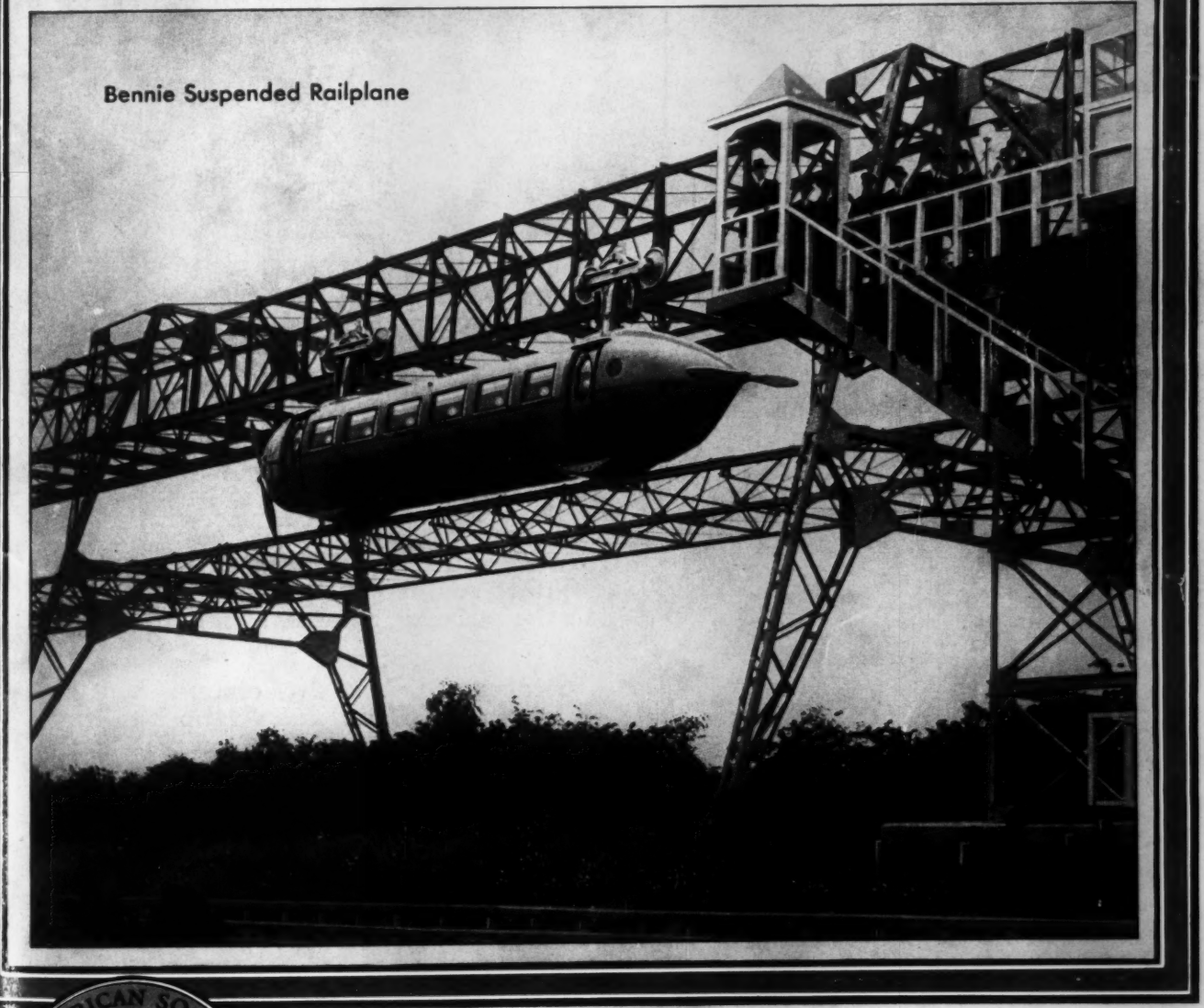
MAR 2 1931

MECHANICAL ENGINEERING

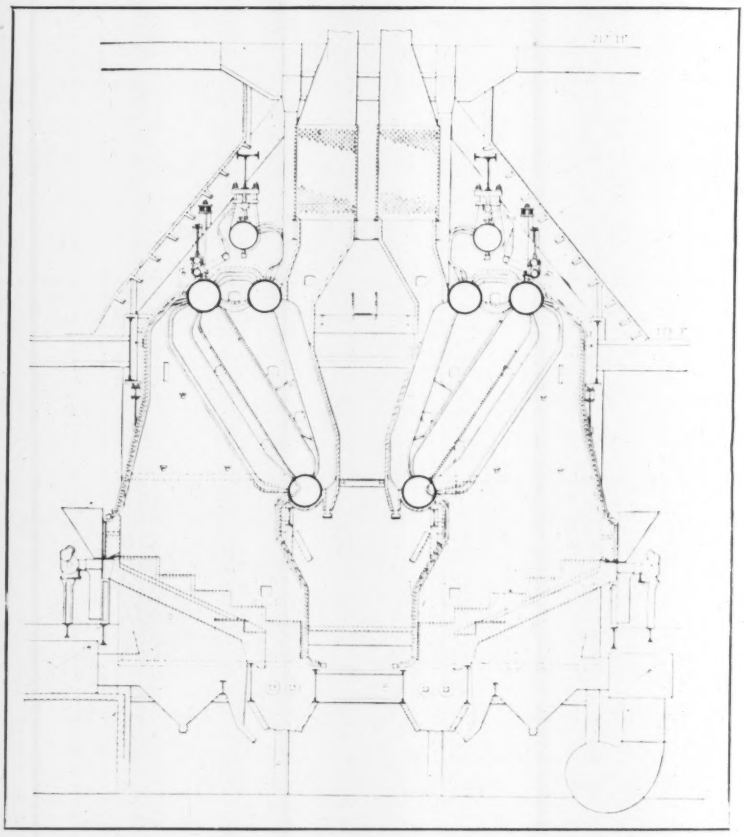


Bennie Suspended Railplane

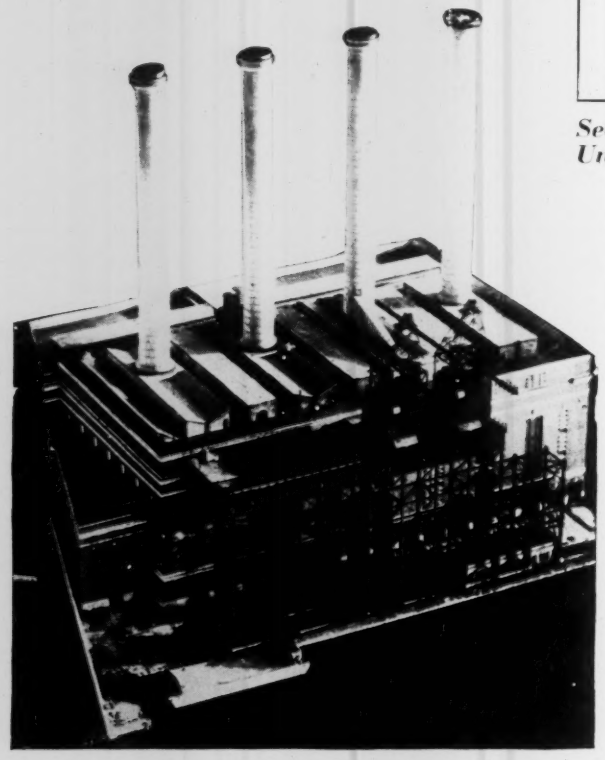
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

March 1931

Eight Combustion Engineering Boilers *to increase* Hudson Avenue Station's Steam Output by over 4,000,000 lb. per hour



Sectional side elevation of two of the eight Combustion Units to be installed in the Hudson Avenue Station of the Brooklyn Edison Company.



Hudson Avenue Station, Brooklyn Edison Co.

The new addition to the Hudson Avenue Station of the Brooklyn Edison Company is designed to provide a maximum of water heating surface and furnace volume within the building space available.

To accomplish this, eight Combustion Engineering Bent Tube type boilers, and eight C-E Water-cooled Furnaces comprise the steam generating surface. Each of the eight units is equipped with a C-E Fin Tube Return Bend Economizer.

COMBUSTION ENGINEERING CORPORATION

200 MADISON AVENUE - NEW YORK

Boilers Pulverized Fuel Equipment Stokers
Water-Cooled Furnaces Air-Preheaters

Mechanical Engineering

The Monthly Journal Published by

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What It's All About

COMPETITION IN THE TRANSPORTATION INDUSTRY is very much in the limelight at present. The railroads have been experiencing one form of competition after another. The automobile and motor truck have taken away much short-haul business. The airplane is a contender where speed is important. Pipe lines are growing in extent. Hydroelectric power distributed over long networks of lines displaces steam-generated power for which the railroads might be hauling coal. Improved waterways, the Panama Canal, and coastal steamship lines also have their effect.

Julius H. Parmelee, director, Bureau of Railway Economics, in the March issue of MECHANICAL ENGINEERING, gives a statistical summary of what competition in the realm of transportation has meant to the railroads.

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ENGINEERING CULTURE was discussed by Prof. H. F. Moore in an address at the Cleveland meeting of the American Association for the Advancement of Science. Culture, as Professor Moore uses the term, is the development of a philosophy of life. It is contended that the popular view of culture should be extended to include the viewpoint of pure and applied science, which substitutes for attempts to prove preconceived theories the humble confession of Galileo, "I know not," and his ardent desire to discover the truth. It is urged that engineers make an indirect contribution to culture by smoothing the path, through their technological developments, to finer manners, taste, and art.

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THE BOILER ROOM OF THE FUTURE will house a gas-fired multicellular boiler of the tube-and-header type, and will also contain the turbine, generator, and auxiliaries, predicts Geo. A. Orrok. His vision of the future of steam power is briefly summarized as follows: All solid fuel for making heat and power will be burned in the gaseous state, necessitating (a) complete gasification plants, (b) coking plants for metallurgical applications, and (c) the development of pipe-line transportation for fuel distribution. There will be developed large-capacity boilers of small physical size, using high speeds and high heat-transfer rates, and necessitating (a) excellent burner practice, (b) absolute safety in construction, and (c) high commercial efficiency. The smoke and dust nuisance from solid fuel in thickly settled communities will thus be largely abolished.

CREEP OF METALS at elevated temperatures is beginning to have a familiar sound in engineering discussions. Designers of equipment, such as valves for use at high temperatures, have been forced to study the plastic deformation or permanent set of metal which results from the continued application of stress under such conditions. Engineers whose knowledge of this important subject is somewhat sketchy will find P. G. McVetty's exposition of the phenomenon instructive and clearly set forth in this month's issue of MECHANICAL ENGINEERING.

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TESTS OF MODELS are a convenient means of analyzing projected designs by experimental methods. Examples of two entirely different techniques are found in the papers by R. E. Peterson on "Fatigue Tests of Model Turbo-Generator Rotors," and by R. V. Baud and E. Hall on "Stress Cycles in Gear Teeth." Mr. Peterson made use of approximately half-size models of turbo-generator rotors and conducted a series of tests on them to determine the effect of alternating fatigue stresses. Later another series of tests in which centrifugal stresses were added was performed in a pit. Messrs. Baud and Hall used celluloid models of gear teeth in photoelastic tests. In such tests stress distribution is indicated by bands of colors when the stressed celluloid is subjected to polarized light. Their present paper reports an extension of work described in previous issues of MECHANICAL ENGINEERING.

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THE FACTOR OF SAFETY was discussed from one point of view in the November, 1930, issue of MECHANICAL ENGINEERING. Another point of view is now expressed by Prof. Frank A. Mickle in the present issue.

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EUROPEAN LABORATORIES for the testing of materials were visited last summer by Franklin L. Everett, of the University of Michigan. Mr. Everett found research held in high respect abroad, and his observations on the work in progress there should serve as a stimulus to similar work in this country.

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A CABLE PLANT has been recently erected by the Western Electric Company at Point Breeze, Md., some features of which J. C. Hanley describes in this issue of MECHANICAL ENGINEERING.

MECHANICAL ENGINEERING

Volume 53 March, 1931 No. 3

Competition in the Transport Industry

Modern Transportation Developments and the Economic Problem Underlying Them—Possibility of Ruinous Strife Among the Several Transport Agencies Unless Solution Is Sought Through Orderly and Intelligent Coordination and Adjustment

By JULIUS H. PARMELEE,[1] WASHINGTON, D. C.

COMPETITION in the realm of transportation has been a recognized factor since the earliest organization of transport agencies. One by one, newer forms of transportation have driven out the older forms, or have reduced them to a less important status. When the steam railways entered the field a century ago, highway transport was of minor importance. The internal-combustion engine, and its application to vehicles, was still on the far-distant horizon. Water transport offered the first competitive obstacle to rail development. Steam as a motive power was first applied to water transportation, and later transferred itself to the rails. Down to the beginning of the present century the railway competed primarily with the waterway, and had all the better of the argument. Even the rise of the electric railway, and particularly the interurbans, failed seriously to affect the steady upward tendency of passenger and freight traffic by steam railway. The latter acquired preeminence in the transport field early in its history, and retained it in the face of all competition.

Since 1900, however, the competitive aspects of transportation in the United States have changed, and the change has shown itself to an intensified degree during the past ten years. The motor vehicle on the highway is offering strong competition as improved highway mileage and the number of motor vehicles have increased. Pipe-line development has been rapid. The increasing production of electricity, and its more extensive transmission by high-power lines, have indirectly affected the movement of coal by rail. Waterway development has entered a period of renaissance, fostered by large governmental appropriations for rivers and canals, and by direct subsidies to the Government-owned barge line on the Mississippi and Warrior rivers. Even the airplane has had its effect.

The present brief survey attempts little more than to measure the extent and effect of these growing elements of competition in the transport field during the past decade. It is an interesting development; it presents many economic problems for the future; and proper solution of those problems will have vast consequences for the nation during the next fifty years.

To a considerable extent, all agencies of transport compete with each other. Water transportation may draw traffic away from the railway, or it may carry traffic that would otherwise move by motor truck. Motor-vehicle movements compete with both rail and water. But the most intensive competition is that between the railway on the one hand and the remaining transport agencies on the other, taken separately or in combination. It is the steam railway against the field. If the succeeding discussion brings out the degree to which various transportation developments have disadvantaged the railways, such a placement of emphasis is not designed as a brief for the rail industry, but is offered merely as a statement of fact and as the presentation of a vital economic problem. No industry has any prior right to public favor, provided it is accorded a fair chance with all its industrial competitors. As the railways themselves have said in a recent formal "declaration of policy:"

> In so far as any form of (transportation) service is legitimate and a natural economic development, the railroads have no right to complain. The public is entitled to the best transportation at the lowest reasonable cost.

Some agencies of transportation have directly influenced the movement of traffic by rail. Other agencies have had an indirect effect, in that they transport

[1] Director, Bureau of Railway Economics. Dr. Parmelee was graduated from Yale University in 1904 (Ph.D., 1910). He was instructor in economics at Yale from 1904 to 1907, when he became special examiner for the Interstate Commerce Commission. In 1909 he was made a special agent of the U. S. Census Bureau, leaving this work in 1911 to become statistician for the Bureau of Railway Economics, of which he has been director since 1920. Dr. Parmelee was editor of the *American Economic Review* from 1915 to 1918. He was a delegate to the International Railway Congress in London, in 1925 and president of Section IV; and delegate to the Third General Conference on Communications and Transit, Geneva, Switzerland, 1927. He is a fellow of the American Statistical Association and a member of the American Economic Association, Railway Accounting Officers' Association, and American Railway Guild. He has been a contributor to *Railway Age*, *Social Science Abstracts*, *Quarterly Journal of Economics*, etc.

materials or power which have displaced commodities ordinarily carried by rail.

The principal agencies of transportation are steam railways, private motor cars, autobuses, auto trucks, waterways, interurban electric lines, pipe lines, airplanes, and hydroelectric-power lines.

It is estimated that the total land-borne and water-borne commercial freight traffic in the United States during 1929 aggregated 650 billion ton-miles, of which 75.8 per cent was carried on the railways, 16.3 per cent on inland waterways (rivers and canals) and the Great Lakes, 4.9 per cent by pipe lines, and 2.5 per cent by motor trucks operating in interurban service; the remaining fraction of one per cent is assignable to interurban electric railways and to airplanes. In this calculation no consideration is given to intercoastal traffic, to foreign traffic into or from the Great Lakes, or to ton-miles that might have accrued had no indirect traffic effect been exerted by pipe-line movement and hydroelectric power production. It is clear that in the general freight-carrying field the steam railway still maintains a premier position, despite the growth of various forms of competition.

The passenger-carrying story is quite different. A curve based on the prewar rate of increase in passenger-miles from 1890 to 1915 on steam roads in the United States, projected by the Interstate Commerce Commission through subsequent years, indicates that the total passenger traffic for 1929 should have approximated 52 billion passenger-miles. Of this amount, less than 32 billion passenger-miles actually accumulated on the railways, leaving 20 billion passenger-miles as a reasonably calculable loss to other agencies, chiefly the individually owned and operated motor car. Passenger travel by rail in 1929 was smaller in amount than in any year since 1909.

Automotive Traffic

Concomitant with and essential to the development of automotive traffic is the development of hard-surfaced roads.

The total mileage of surfaced roads of all types in state, county, and local highway systems aggregated 387,760 miles in 1921. This total has grown steadily year by year, and in 1929 amounted to 662,435 miles, an increase of nearly 71 per cent over 1921. The increased mileage of roads surfaced with sand, clay, or gravel, 1929 over 1921, amounted to about 83 per cent, and that of macadam roads, 13 per cent; while the mileage increase in asphalt and concrete roads, the type of highway conducive to the increased use and range of motor transportation, was 245 per cent.

Highways improved with the aid of Federal funds increased at a much faster rate than other surfaced roads. The aggregate mileage of surfaced roads in state and Federal highway systems increased from 84,858 miles in 1921 to 208,324 miles in 1929, an increase of 145 per cent, while the mileage of county and local roads increased from 302,902 miles to 454,111 miles, or 50 per cent.

Motor-Vehicle Registrations. Coincident with the development of improved highways, motor-vehicle registrations have greatly increased since 1920. Whether the growing number of motor cars has stimulated the development of good roads, or whether highway development has done more to stimulate automobile production, both developments have influenced each other.

Passenger-car registrations (including bus registrations) aggregated 8,225,859 units in 1920. They increased to 23,121,589 units in 1929, a growth of 180 per cent. Approximately 10,000 autobuses were included in the registrations for 1920, and in 1929 approximately 92,500, an increase of 825 per cent through the period. The bus figures cover both revenue and non-revenue buses, the latter being those used for school purposes, by institutions, and the like.

Motor-truck registrations in 1920 aggregated 1,006,082 units, while in 1929 they amounted to 3,379,854 units, an increase of 235 per cent.

During the period the average carrying capacity of both passenger buses and motor trucks increased considerably.

Motor Passenger Traffic. Passenger traffic by private (that is, non-commercial) automobile is not easily calculable. It has been estimated, however, that passenger automobiles (other than buses) average about 5000 miles annually, that an average of $2^1/_2$ passengers are carried per car, and that about one-half of the total passenger-car mileage is made on the rural highways, that is, in interurban travel. On this basis, the total number of interurban passenger-miles in 1929 approximated 145 billion. Passenger-mileage on the steam railways in 1929, it will be recalled, was less than 32 billions.

Some general statistics are also available for autobus passenger traffic. Buses operating in interurban service represent about three-tenths of the total bus registration. Travel by interurban bus amounted to approximately 4,375,000,000 passenger-miles in 1926 and 6,797,000,000 passenger-miles in 1929, an increase during the four years of 55 per cent.

Motor-Truck Traffic. Detailed information with respect to the extent of motor-truck traffic is not available, but some idea of its growth may be secured from the following facts.

Motor-truck registrations increased 235 per cent between 1920 and 1929. Making allowance for a gradual increase in unit capacity during that period, and for the more extensive use of trucks for the movement of freight in interurban service, it is estimated that in 1929 more than 15 billion ton-miles of commercial freight was moved by truck between cities and towns.

The number of head of live stock transported by truck to sixteen large markets is reported by the United States Department of Agriculture as 2,864,716 in 1919. Ten years later, in 1929, truck receipts of live stock at the same sixteen markets amounted to 13,775,905 head, an increase over 1919 of 380 per cent. During the same period rail receipts of live stock at these same markets declined 27 per cent.

Returns to the Department of Agriculture also show

that a total of 47,196 equivalent carloads of fresh fruits and vegetables were unloaded from trucks at 12 large markets in 1929. This represented nearly 13 per cent of the total unloads of fresh fruits and vegetables by rail and truck combined.

WATERWAY TRAFFIC

Water-borne traffic in the United States has increased greatly during the last decade. Evidence of this is found in the records pertaining to the inland waterways, the Great Lakes, and the Panama Canal.

Inland Waterways. The term "inland waterways" is here used to denote rivers, canals, and connecting channels, exclusive of the Great Lakes and the lake-connecting channels. It excludes, of course, the open sea and coastwise routes. Net tons of commerce handled on our inland waterways, including duplications due to traffic passing from one river section to another, aggregated 82,000,000 tons in 1921 and 171,000,000 tons in 1929, an increase of more than 100 per cent.

Traffic on the Mississippi and its tributaries forms a part of the inland-waterway movement. Mississippi-system traffic amounted to 44,000,000 tons in 1921 and 78,000,000 tons in 1929, an increase of 77 per cent.

Great Lakes. Accurate figures of total traffic on the Great Lakes are difficult to secure. According to reports of the United States Army Engineers, however, a good measure of the growth of commerce on the Great Lakes is the traffic passing through the St. Marys Falls Canal, also known as the Soo Canal. The total freight passing through this canal aggregated 48,300,000 tons in 1921, while in 1929 it was 92,600,000 tons, an increase of about 92 per cent.

For the two types of waterway systems discussed above (inland waterways and the Great Lakes) the freight carried during the year 1929 aggregated 105,983,000,000 ton-miles, or 16.3 per cent of the estimated ton-miles of commercial freight traffic by all transportation agencies. Breaking this total down, 97,322,000,000 ton-miles accrued on the Great Lakes and 8,661,000,000 on the inland waterways. Comparable statistics of ton-mileage for 1921 are not available.

The bulk of the commercial traffic on the inland waterways, as well as a large part of that on the Great Lakes, moves in competition with rail routes.

Panama Canal. In addition to the water-borne traffic which has just been described, a large part of the traffic moving through the Panama Canal comes into direct competition with the railroads. This part comprises principally the intercoastal traffic, or traffic moving from the Atlantic to the Pacific coast, or from the Pacific to the Atlantic coast, through the Panama Canal.

The total traffic passing through the Panama Canal aggregated 11,599,000 long tons during the fiscal year ended June 30, 1921, of which 1,372,000 tons, or 11.8 per cent, moved in intercoastal trade. In the fiscal year 1930 the total traffic amounted to 30,030,000 long tons, of which 10,490,000 long tons, or 34.9 per cent, moved in the intercoastal trade. Not only was there a large actual increase in intercoastal traffic, but also a large relative increase. The actual increase from 1921 to 1930 was 9,118,000 long tons, or 665 per cent.

Analyzing the intercoastal trade in 1930, 3,162,000 tons moved from the Atlantic to the Pacific seaboard, and 7,329,000 tons from the Pacific to the Atlantic. The westbound movement was 70 per cent of intercoastal total, and the eastbound movement 30 per cent.

Had the 10,490,000 long tons, or 11,749,000 equivalent short tons, of canal traffic handled in United States intercoastal trade in 1930 been transported across the United States by rail, the total ton-mileage by rail would have been 30 billion. However, this was not a net loss to the rail carriers, because they usually secure a haul at one or both ends of the water movement: from some inland point to the port of origin, and from the terminal port to some other inland point.

THE economic question underlying these transportation developments [highway, waterway, airway, pipe line, electric power line] goes much deeper than their effect on the railways. Are the developments economically sound? Will they, continued over the next half-century, assure the nation that adequacy and efficiency of transportation service that is its due? Will the problem gradually expand into a fight to the finish among the several transport agencies, or will it approach solution through an orderly and intelligent process of coordination and adjustment? These are searching questions, but they call for study and should receive thoughtful attention from engineers, economists, transportation men in all fields, public administrators, and business leaders. Otherwise, we may be headed for a period of economic readjustment that will create more problems than we can now foresee.

Coastwise Shipments. Another element in the competition for rail traffic is represented by coastwise shipments other than intercoastal traffic through the Panama Canal. No accurate figures are available as to the amount of this traffic, but evidence indicates that it is considerable.

ELECTRIC-RAILWAY TRAFFIC

Complete information with respect to the traffic of all electric lines is not readily available. Electric lines engaged in interstate commerce, however, make reports to the Interstate Commerce Commission. A total of 303 lines in 1921, operating 14,438 miles of road, reported freight revenues of $28,705,000, while 211 lines in 1929, operating 10,076 miles of road, reported freight revenues of $38,042,000. The decline in number of roads and in number of miles operated was probably due to consolidations and abandonments. There was, however, an increase of $9,337,000 in freight revenues during the period, or 33 per cent.

Statistics of passenger revenue are not available prior to 1925. In that year, passenger revenues reported by 260 roads aggregated $152,967,834, while

in 1929, for 211 roads reporting, they aggregated $102,521,739, a decrease of $50,446,095, or 33 per cent. This decline was undoubtedly due in large part to competition from private passenger automobiles and from autobuses.

AIR SERVICE

Airplane service has made great strides in recent years, and consists of the air transportation of mail, passengers, freight, and express.

Mail. Regular transportation of mail by airplane in the United States had its inception on May 15, 1918, when air-mail service was inaugurated between Washington and New York, a distance of 218 miles. Many other routes have since been established, some of which were subsequently abandoned. The number of routes in actual operation on June 30, 1930, aggregated 32, with a total length of 14,907 miles.

According to reports of the Postmaster General, on the basis of forty letters to the pound, 17,831 lb. of mail were transported by plane during the period May 15 to June 30, 1918, and 230,251 lb. during the fiscal year ended June 30, 1919. From that time to the end of the fiscal year 1923 the increase was rapid. Mail transported in 1923 aggregated 1,696,896 lb. In 1924 there was a decline to 1,500,034 lb.

Up to this time practically all mail carried by plane was transported in the daytime and at ordinary rates of postage, but on July 1, 1924, night flying began and postal rates by air mail were increased.

During the fiscal year 1925 a total of 232,513 lb. of air mail was carried by plane at the higher rates of postage. This increased steadily, year by year, up to 7,719,698 lb. in 1930. During 1927 the larger part was carried under contract by private air-transportation lines, and since that year all the air mail has been carried in that manner.

Had there been no air service in 1930, and had the railways been required to provide *additional space* for the service involved in the transportation of mail by plane, the revenues to the railroads for the carriage of mail would have been appreciably greater.

Passenger. According to figures published by the aeronautics division of the United States Department of Commerce, passenger service by airplane has made considerable progress since 1926. During that year 5782 passengers were carried by air-transport lines operating on regular schedules, while 173,405 passengers were carried in 1929.

The first coast-to-coast combined air-rail service became a reality in 1929. In that same year the world's first regular night passenger route in tri-motored planes was inaugurated.

The year 1930 saw considerable growth over 1929. Reports of the Aeronautical Chamber of Commerce show that regularly scheduled air lines carried 255,631 passengers during the first nine months of 1930, or about 80,000 in excess of the entire peak year of 1929. These reports also indicate that each of the nine months showed a consistent increase of several thousand passengers over the preceding month, with the exception of a slight seasonal decline in September. The average passenger traveled a distance of 245 miles on each trip in 1930.

Freight and Express. In addition to mail and passenger services, regularly scheduled air lines transported an average of approximately 1,900,000 pounds of freight and express annually during the four years 1926 to 1929.

PIPE-LINE TRAFFIC

Crude-Oil Lines. In the earlier years of the petroleum industry, crude oil was transported largely by rail, but in recent years it has been transported chiefly by pipe line. This has been especially true during the last decade.

Production of crude petroleum in the United States aggregated 442,929,000 bbl. in 1920 and 1,007,323,000 bbl. in 1929, an increase of 127 per cent.

Pipe-line companies reporting to the Interstate Commerce Commission operated 53,043 miles of lines in 1920 and 85,796 miles in 1929, an increase during the ten years of about 62 per cent. Supplementing this increase in length of line there was also an increase in diameter of the pipes, with a cumulative effect on total carrying capacity.

Crude petroleum transported by these pipe lines, (including duplications) amounted to 533,180,000 bbl. in 1920 and to 1,156,351,000 bbl. in 1929, an increase of 117 per cent.

The total of crude petroleum originating on Class I railways in the United States was 6,435,074 short tons in 1920, while in 1929 it amounted to 6,630,354 tons. In equivalent barrels of 42 gal. and on the basis of 300 lb. to the barrel, the increase was from 42,900,000 bbl. in 1920 to 44,200,000 bbl. in 1929, an increase of 1,300,000 bbl., or 3 per cent. This small increase of 3 per cent is striking when contrasted with the large increases of 127 per cent in production and 117 per cent in pipe-line transportation over the same period.

Gasoline Pipe Lines. Gasoline is transported chiefly by rail. Together with that of other refined-oil products, this movement has shown a considerable increase in past years. At present, transportation of gasoline by pipe line is largely in an experimental stage. Some lines are being operated, while others are under construction. Developments are being closely watched, and as the technical difficulties are overcome, other lines will doubtless be inaugurated. These will probably parallel the highways, as they appear to offer the best opportunity for sales.

Gas Pipe Lines. Natural gas is transported entirely by pipe lines. There are now between 60,000 and 80,000 miles of natural-gas lines in the United States. Additional lines are being rapidly constructed, and others are contemplated. The natural gas produced and marketed in 1929 amounted to 1900 billion cubic feet, an increase of 22 per cent over the year 1928.

Taking a basis of one ounce of coal as roughly equivalent in heating value to one cubic foot of gas, the 1929

sales of gas displaced about 59,000,000 tons of coal. This indirectly affected the movement of coal by rail.

HYDROELECTRIC POWER

The use of electric current for power transmission has greatly increased the importance of falling water as a source of energy. The output of electricity generated by water power in public-utility electric plants aggregated 14,970 million kilowatt- hours in 1921, while in 1929 it was 34,629 million, an increase of 131 per cent.

Based upon the average consumption of fuel in the production of electric energy in 1929, which was equivalent to 1.69 pounds of coal per kilowatt-hour, the amount of fuel displaced by hydroelectric energy in 1929 was equivalent to 29,261,505 tons of coal, which might have been hauled by the railroads had the equivalent power not been developed and transmitted by power lines.

Power developed by public-utility power plants using coal or oil for fuel also showed a large increase. Their output rose from 24,315 million kilowatt-hours in 1919 to 62,723 million kilowatt-hours in 1929, an increase of 158 per cent. The railways doubtless hauled fuel for these plants. If it be true that electric power is a more economical and efficient method of fuel utilization than power applied by steam or by belt, rail carriers lost some traffic because of this increase.

EFFECT ON RAIL TRAFFIC

The full effect of the growth of these competitive agencies of transportation on the traffic of the steam railways is not calculable with any degree of accuracy. They have taken traffic from the railways; their development has brought certain types of traffic to the railways that otherwise would not have moved at all; the net effect, however, has been to reduce railway traffic as a whole to an almost static position.

Traffic statistics of the railways show that revenue ton-miles increased from a total of 414 billion in 1920 to 450 billion in 1929, an increase during the ten-year period of 9 per cent; while revenue passenger-miles declined from 47 billion miles in 1920 to less than 32 billion in 1929, a decline of 34 per cent.

Traffic units, that is, ton-miles plus passenger-miles (equated by regarding 3 ton-miles as equivalent to one passenger-mile), showed a decrease of two per cent during the period 1920 to 1929.

While the steam railway is still the principal commercial freight carrier of the country, it handles a much smaller proportion of the interurban passenger travel than the private automobile, autobus, electric railway, and airplane combined. Roughly computed, the railways account for about three-fourths of the freight traffic, but for less than one-fifth of the interurban passenger travel.

A review of transportation development during recent years brings out many contrasts. These are presented in the next column in tabular form.

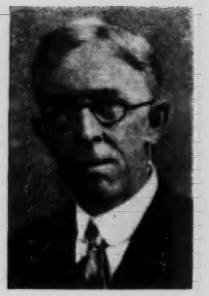
Item	Per cent of Increase	Per cent of Decrease
Railways:		
Revenue ton-miles, 1920 to 1929	9	
Revenue passenger-miles, 1920 to 1929		34
Traffic units, 1920 to 1929		2
Other Transportation Agencies:		
Miles of surfaced highways, 1921 to 1929	71	
Miles of surfaced highways, state and Federal, 1921 to 1929	145	
Miles of surfaced highways, county and local, 1921 to 1929	50	
Automobile passenger-car registrations, 1920 to 1929	180	
Autobus registrations, 1920 to 1929	825	
Motor-truck registrations, 1920 to 1929	235	
Revenue passenger-miles, interurban buses, 1926 to 1929	55	
Truck receipts of live stock at 16 markets, 1919 to 1929	380	
Net tons commerce on rivers, canals, and connecting channels, 1921 to 1929	110	
Freight traffic on Great Lakes, 1921 to 1929	92	
United States intercoastal freight traffic through Panama Canal, 1921 to 1930	665	
Freight revenue, interstate electric lines, 1921 to 1929	33	
Passenger revenue, interstate electric lines, 1925 to 1929		33
Mail carried by airplane, 1925 to 1930	3220	
Passengers carried by airplane, 1926 to 1929	2899	
Miles of pipe line (crude petroleum), 1920 to 1929	62	
Crude-petroleum production, 1920 to 1929	127	
Crude petroleum transported in pipe lines, 1920 to 1929	117	
Kilowatt-hours of hydroelectric power, 1919 to 1929	158	

Had the railways of the United States in 1929 transported all of the freight and passenger traffic involved both directly and indirectly in the activities of the competitive agencies here discussed, their gross operating revenues in that year would have been greater than they were by 40 to 50 per cent. Assuming that the railways had carried this additional traffic at the same operating ratio as for actual rail transportation in that year, including operating costs, tax assessments, and other costs which follow the revenues, the net operating revenues would also have increased considerably. This estimate makes allowance for the increased track, locomotive, and car capacity that would have been made necessary by the greater traffic demand.

But the economic question underlying these transportation developments goes much deeper than their effect on the railways. Are the developments economically sound? Will they, continued over the next half-century, assure the nation that adequacy and efficiency of transportation service that is its due? Will the problem gradually expand into a fight to the finish among the several transport agencies, or will it approach solution through an orderly and intelligent process of coordination and adjustment? These are searching questions, but they call for study and should receive thoughtful attention from engineers, economists, transportation men in all fields, public administrators, and business leaders. Otherwise, we may be headed for a period of economic readjustment that will create more problems than we can now foresee. Shall we drift into and through this period without a rudder, or is there a guiding hand to steer the transportation bark safely through these troubled waters?

Engineering Culture

By H. F. MOORE,[1] URBANA, ILL.



AT THE outset of this discourse it seems necessary that we should define what we mean by culture. The conventional thing to do is to quote an authoritative dictionary, but here we are met with difficulty. The word "culture" has seven or eight different definitions, varying all the way from "the details of a map which do not represent natural features of the area delineated," to the definition, "refinement in manners and tastes." By some of our artist friends culture is regarded as measured by the production of works of art, while our friends the philosophers would doubtless insist that culture includes the formation of a philosophy of life. For our present purposes we may perhaps regard culture as "the training, disciplining, or refining of the moral and intellectual nature."

Cultured Men May Be Narrow Minded

I wish to point out that, taken in the sense of refinement of manners and morals, or in the artist's sense of production of works of art, a cultured man may be very narrow minded. In Conan Doyle's novel "Sir Nigel" the young squire visits an old authority on the culture of knighthood, and the old knight is anxious above all else that his young friend shall always use exactly the correct word, lest he be the cause of laughter to his hearers and of grief to his friends. Especially must he recognize the fact that each species of animal has a distinctive name to designate a group. One must *never* speak of a *herd* of lions, but rather of a *pride* of lions. To speak of a *flock* of pheasants is a grievous sin against culture—it is a *nye* of pheasants. Similarly today there are many guardians of culture who are more shocked at a misspelled word (even in our quite unsystematic English spelling) than at a hazily expressed thought. Many there are who boast themselves as liberals who are as deeply distressed as the strictest Pharisee at any infraction of any detail of the current social or literary code. If we limit the field of culture to literature, art, and music we are in truth shutting out from any philosophy of life a consideration of many viewpoints which, be they good or evil, are certainly powerful today. I wish at this time to maintain, first, that if we regard culture as the "training, disciplining, and refining of the moral and intellectual nature," we are not justified in excluding from any system of general culture a consideration of the viewpoint either of the scientific *method* or of *applied science*. Why should we call uncultured the man who knows thoroughly and broadly the history and philosophy of the heat engine but is ignorant of the music of Brahms, while we hail as cultured the musician who is a master of technique and knows the field of harmony but is contemptuous of the applied science which has made possible the modern pipe organ.

I wish to make it very plain that I do not myself despise nor do I wish any engineer to despise the viewpoint of the philosopher, the artist, the writer, the musician, the student of literature, or the theologian. I do maintain, however, that no one of these—no, nor all of them put together—has the basis for a complete disciplining of the moral nature if he leaves out of consideration the work and the methods of thought of the applied scientist. I admire Plato, read his works (in translation) with interest, and am glad he lived and that his work survived, but do not believe that Plato is a *complete* guide for living and working.

It may be objected that the field for culture proposed is so broad that no man can thoroughly master it all. This is true. No man can master the whole field of art, of literature, of pure science, or of applied science. However, he may hope to master some part of one field, and to be an interested and respectful observer of other fields. The jack of all trades and master of *none* is not an admirable figure, but the jack of all trades and the master of *one is*, and is more deserving the title of cultured man than is the super-master of one trade who despises all others. The narrow specialist, be his specialty music or hog breeding, poetry or heat engines, is frequently, especially at times of crisis, a most useful citizen, but he does not embody a high degree of culture.

Accepting the idea that culture includes as a major object the development of a philosophy of life, the speaker believes that the engineer has some positive contributions to make to such a philosophy. Perhaps the positive contributions are not so great as the indirect, and this point will be discussed later.

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Vice-presidential address before Section M (Engineering), American Association for the Advancement of Science, Cleveland, Ohio, December 30, 1930.

CULTURE SHOULD BE BROADENED TO INCLUDE THE VIEWPOINT OF PURE AND APPLIED SCIENCE

One positive contribution toward a development of culture which the engineer is well fitted to make, or at least to emphasize, is the demand that the field of interest underlying such a philosophy be broadened to include not only the viewpoint of pure science but the application of that viewpoint to the affairs of daily life, and a consideration of the resultant effect upon our thinking. Far from wishing to belittle the importance of the classical viewpoint of culture, let me express my admiration—a rather uncritical admiration—of it, and my belief that all modern thinkers, including all engineers, might well become more familiar with the classical viewpoint. However, one characteristic attitude of that culture—the frank placing of the affairs of earning a livelihood in an *inferior* class—I believe to be a fault of that culture and not a virtue. An effect of that fault is plainly illustrated by the inability of the great minds of the classical world to develop the science of mechanics beyond a most elementary stage. It was not until an entirely new frame of mind came in under Galileo—a frame of mind which in the search for knowledge and in the development of the philosophy of life "called nothing common or unclean"—that the science of mechanics, the first ripening fruit of the scientific age, was able to develop.

I WOULD urge to engineers, first, that they accept openly and unashamed their function as smoothers of the path for the development and refinement of manners and morals. I would urge that they insist upon the dignity of this work, not noisily but firmly. The great artist who paints a picture before which men and women dream is more notable than the chemist that developed for him the pigments which he used and the textile expert who has made possible the canvas on which he paints; but the artist falls short of the full stature of culture if he holds chemists and textile experts in contempt. I am asking not for formal praise to the engineer as the smoother of the path, but I am asking him to keep his own inner conviction of the worth-whileness of his task, and to honor worthy writers, painters, musicians, and artists, not as a higher class of beings but as workers who also have done well.

The essentially aristocratic attitude of superiority to those who have to work for a living is not necessarily snobbish, but easily sours into snobbishness, and a contribution to a philosophy of life which presupposes that no phase of life is unworthy the attention of a scholar may well be emphasized again and again by the engineer.

THE ENGINEER'S IDEA OF TOLERANCE A CONTRIBUTION TO CULTURE

A second positive contribution to culture may well be the engineer's idea of tolerance. In general we think of tolerance as a kindly, somewhat careless virtue whereby we recognize that there is much bad in the best of us and much good in the worst of us, and so why worry much about it. To the engineer, tolerance carries an entirely different meaning. He states, for example, that in making steel for rails there is allowed a tolerance of $^1/_{20}$ of 1 per cent of phosphorus. That does not mean that he refuses to worry about phosphorus in steel. He worries about it a great deal, and as a result of his intelligent worrying he has decided that the cost and the time of removing that last $^1/_{20}$ of 1 per cent of phosphorus from steel is too high, whereas there is evidence that the material damage done by such a small amount of phosphorus is very slight. Therefore he places a limit below which it is not wise to reduce phosphorus.

This idea of a sort of tolerance of those manners and morals which seem to us undesirable is suggested as a contribution to culture. We should by no means be good-naturedly careless about the undesirable things, but we may well try to develop a careful discrimination in choosing those evil things which we shall try to eliminate and the good things which we shall try to encourage; and we realize that as absolute perfection is never reached in the chemical and mechanical world, so there are limits of perfection beyond which effort in the social and ethical world is ineffective, and that these limits are not fixed but vary from age to age.

DEVELOPMENT OF ABSTRACT IDEALS AS THE RESULT OF DAILY WORK

A third positive contribution which the engineer may make to culture is the pointing out of the fact that not infrequently development of abstract ideals may come as the result of daily work on the job. Perhaps such development may come from the day's work as often as from abstract thinking. In the engineer's professional life the immediate thing before him is always a job, but frequently as he wrestles with a job, general ideas of the relation of his job to various other jobs and of the development of various values and general truths come to him. The engineer reacts with hearty approval to that statement of the Carpenter of Nazareth, "If any man will do his will, he shall know of the doctrine," and the speaker believes that the engineer may well contribute to culture by the insistence of the fact that the road between the shops of the doers of jobs and the studies of thinkers of thoughts is not a one-way street.

The speaker has mentioned what he believes to be some positive contributions of engineering to culture. These contributions make up only a small part of the body of culture, and the fact should be emphasized that many phases of culture are outside the professional field of the engineer, and that he should cultivate an attitude of interest toward them, even though it is not feasible for him to make direct contributions to these phases. Very few engineers can make noteworthy contributions to the art of music, yet the engineer may well regard music as important in the scheme of things.

INDIRECT CONTRIBUTIONS OF THE ENGINEER TO CULTURE

The greatest contributions of the engineer to culture are indirect contributions. Some early records of the

Christian Church at Ephesus have been unearthed, probably for the period about 300 A.D. In those records we find that the preacher of the church was set apart to his sacred office by the solemn laying on of hands. We find that the director of the music of the church was likewise ordained to his position with the solemn laying on of hands. We find also that the janitor was ordained to his office with the solemn laying on of hands. They had some good ideas in those times. Apparently they recognized that the work of the man who saw that the church building and vessels were orderly and clean was worthy of sacerdotal recognition. The engineer should be regarded as a sacristan for the temple of civilized society, and the office of sacristan should be restored to its ancient Ephesian dignity. For the fine arts, the fine tastes, the fine manners may develop amid conditions of hunger, cold, poor housing, and difficult transportation, but these conditions are usually handicaps and not helps.

Function of Engineers in Smoothing the Path to Finer Manners, Taste, and Art

I would urge to engineers, first, that they accept openly and unashamed their function as smoothers of the path for the development and refinement of manners and morals. I would urge that they insist upon the dignity of this work, not noisily but firmly. The great artist who paints a picture before which men and women dream is more notable than the chemist that developed for him the pigments which he used and the textile expert who has made possible the canvas on which he paints; but the artist falls short of the full stature of culture if he holds chemists and textile experts in contempt. I am asking not for formal praise to the engineer as the smoother of the path, but I am asking him to keep his own inner conviction of the worth-whileness of his task, and to honor worthy writers, painters, musicians, and artists, not as a higher class of beings but as workers who also have done well.

But we may face the fact that with the smoothing of the path to finer manners, finer tastes, finer art, there has developed a great tendency for people to loiter along the smooth path, making their own existence a pleasant, aimless journey. Frequently the engineer is blamed for the fact that men have used in this lazy fashion the highway he has helped to prepare or that some of them have actually walked backward on it toward the things that are ugly and cruel. The engineer-physicist who has developed the modern talking moving picture is blamed because there has been disclosed so large a group of people incapable of entertaining themselves and who have become slaves to professional entertainment at so much per head. The automotive engineer is blamed for the daily crowds of people who go on joy rides and frequently spoil all pleasure in riding. The chemical engineer is blamed for the hellishness of poison-gas warfare. Some blame must be taken by the engineer for this state of affairs. In common with the great multitude of people, he has failed to raise his voice very loudly against the abuse of the smooth roadways he has made possible. He, with others, has carelessly assumed that, given an easier pathway to the fine things of life, people will of course seek them. But his blame is not greater than that of other groups of workers. He must take his share of the blame, but he is not a sinner above other men in this respect.

The engineer, with other folk, must come to recognize that while clearing the ground is an important and dignified part of the process of building the temple of society, and that while in dignity and worthiness it is second to no other task, yet the clearing of the ground does not insure that a beautiful temple will be built, and that emphasis must be placed on the proper use on the facilities he has helped create. In considering the proper use of the facilities made available by applied science—surely a field of study of vital importance to culture—the speaker believes that the engineer may well emphasize the necessity of giving due consideration to the viewpoint of the workaday world—not an emphasis which overshadows the viewpoint of the leisurely scholar who is freed from anxiety for daily bread, but an emphasis which will cause attention to be given to *both* viewpoints—a really broad-minded emphasis. He may well emphasize the engineer's idea of tolerance. Moreover he must avoid the great error rather common to the artist type: the tendency to see everything outside one's own field as through a reversed telescope, small and unimportant. And just as the engineer demands that the dignity of his work for humanity be recognized, so must he be willing to give adequate recognition to the viewpoints which preachers and economists, artists and philosophers, authors and pure scientists may have.

The Dimensions of Temperature

AS REGARDS temperature, we may regard it (1) as being a fundamental quantity; or (2) as having no dimensions at all; (3) as heat divided by mass; or (4) as energy.

Choice No. 1, which regards mass, length, time, and temperature as the four fundamental quantities, enjoys a practical advantage, in that the methods of dimensional analysis are able to show how temperature enters into problems of heat flow.

If, on the other hand, we adopt choice No. 2, and select only three fundamental units, length, mass, and time, suppressing the dimensions of temperature, the various physical quantities concerned have the dimensions which are correctly given in Kaye and Laby's Tables, in which also the dimensions of temperature are clearly taken as zero in mass, length, and time.

Again, we may assign dimensions L^2T^{-2} to temperature (choice No. 3), and obtain a third consistent set of dimensional quantities. Similarly, choice No. 4 could be utilized in developing still another set. —G. W. C. Kaye in a letter in *Engineering*, December 19, 1930, p. 783.

Planning a Plant for the Manufacture of Lead-Covered Telephone Cable

Results of a Study to Determine the Size and Type of Building to Be Erected, the Arrangement of Machinery for the Most Direct Handling of Product During Process of Manufacture, and the Most Efficient Materials-Handling Equipment

By J. C. HANLEY,[1] NEW YORK, N. Y.

IN THE fall of 1928 the demand for telephone cable increased to such an extent that it became evident to the management of the Western Electric Company that it would be necessary to provide increased cable-manufacturing facilities. After studying the possibility and advisability of expanding its two existing cable-manufacturing plants, one located at Chicago and the other at Kearny, New Jersey, it was decided that it would be necessary to build a new one and also to expand the existing Chicago plant. A study of the territorial demands for telephone cable indicated clearly that the new plant should be located in the East and should be accessible to deep water to take advantage of the low water-freight rates. Numerous cities and sites along the middle Atlantic seaboard were investigated, and after several months of exhaustive study it was decided to locate the new plant at Baltimore, Maryland.

The site selected for the plant is a peninsula bounded on one side by the Patapsco River, which affords access to deep water, and on the other side by Colgate Creek, a comparatively shallow tributary. Fig. 1 is an aerial photograph showing the cable plant under construction and after filling operations had been started. The solid black line indicates the boundary of the property purchased and the further enlargement possible by filling out to the established bulkhead line. The plans for occupying the property were worked out on the basis that the original dry-land areas would be utilized for the erection of buildings, reserving the filled areas for yard spaces.

In order that the plant might be readily accessible from the city of Baltimore, a strip of land was dedicated to the municipality for a public thoroughfare. The new street was located so as to place the bulk of the property on the deep-water side, and all of the manufacturing buildings and transportation systems have been planned so that they will be located on this side of the new highway.

The cable plant, which was the first unit to be erected, is 533 ft. long, with space between it and the adjacent plant to the west to permit of expansion to an ultimate length of 933 ft. It is a single-story structure and extends for a distance of 660 ft. perpendicular to the highway. Sufficient height under the roof trusses has been provided so that overhead bridge cranes can be operated in any bay of the structure.

Fig. 2 shows the general arrangement of the cable plant, the location of equipment in the building and the routing of the material in the process of manufacture. It will be noted that all permanent facilities such as railroad sidings, for receiving raw materials and shipping finished cable, have been located along the east and south sides of the plant, keeping the west end of the building free of such occupancies so that the plant can be readily expanded in a westerly direction. Raw material in the form of copper and paper enters the plant at the northeast corner, being unloaded from cars in a train shed along the east side of the main plant. These raw materials are placed in steel containers, the loaded containers being moved into the copper and paper storage area by means of electrically operated lift trucks. Fig. 3 shows an electric truck with a loaded skid delivering copper wire to the insulating machines. Similar trucks are used to handle raw materials in skids to the storage area. The initial plant, 533 ft. long, leaves room for approximately 30 per cent expansion over the initial machinery installation without increasing the size of the building, and under these conditions there is ample room in the raw-material storage area for storing the copper and paper in skids in a single layer on the floor. Later as additional machinery is installed it will become necessary to stack the skids upon one another, and special skids have been designed to be stacked by cranes after delivery to the

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[1] Superintendent of Plant Engineering, Western Electric Co., Inc. Mr. Hanley was born in Ohio and attended Cincinnati University and Purdue University. For the past twenty years he has been employed by the Western Electric Company, Inc., with the exception of approximately eighteen months during the World War, during which time he served as first lieutenant in the Ordnance Department and Chemical Warfare Service. His service with the Western Electric Company consisted principally of machine and process development work until 1926, when he was transferred to its newly formed factory planning branch. In this new work he was in charge of factory planning in connection with the rebuilding of the cable plant at the Chicago Works, and when it was decided to start a new plant in the East he was transferred first to the New York office and later to the Baltimore works in charge of factory planning. Upon completion of the first two units of the new Baltimore works, the cable plant and insulated-wire plant, he was again transferred to the New York office to take charge of the design of buildings and power plants for all works.

For presentation at the "Three-M" (Management, Materials, Maintenance) Congress, to be held in Cleveland, Ohio, April 13 to 18, 1931, under the auspices of the A.S.M.E. and the S.I.E. Abridged.

storage area. Fig. 4 illustrates the special skids being stacked by means of a crane.

When copper wire and paper are delivered to the insulating machines which initiate the manufacturing operations, the loaded steel containers will be unstacked by cranes in the storage areas and delivered to a "pick-up space," from which they will be delivered to the insulating machines by electrically operated lift trucks. The raw-material containers are of approximately 24 cu. ft. capacity and weigh approximately 3500 lb. when loaded with copper.

FIG. 1 POINT BREEZE PLANT SITE—W. E. CO., INC., SITE-DEVELOPMENT WORK WELL UNDER WAY

The machinery in the plant has been arranged for as nearly as possible straight-line manufacture, so that the finished product is shipped in the south bay the farthest removed from the raw-material storage area. The intervening space has been divided into manufacturing bays paralleling the raw-material storage bay, and the machinery has been installed so that in general the product passes through the successive operations from north to south.

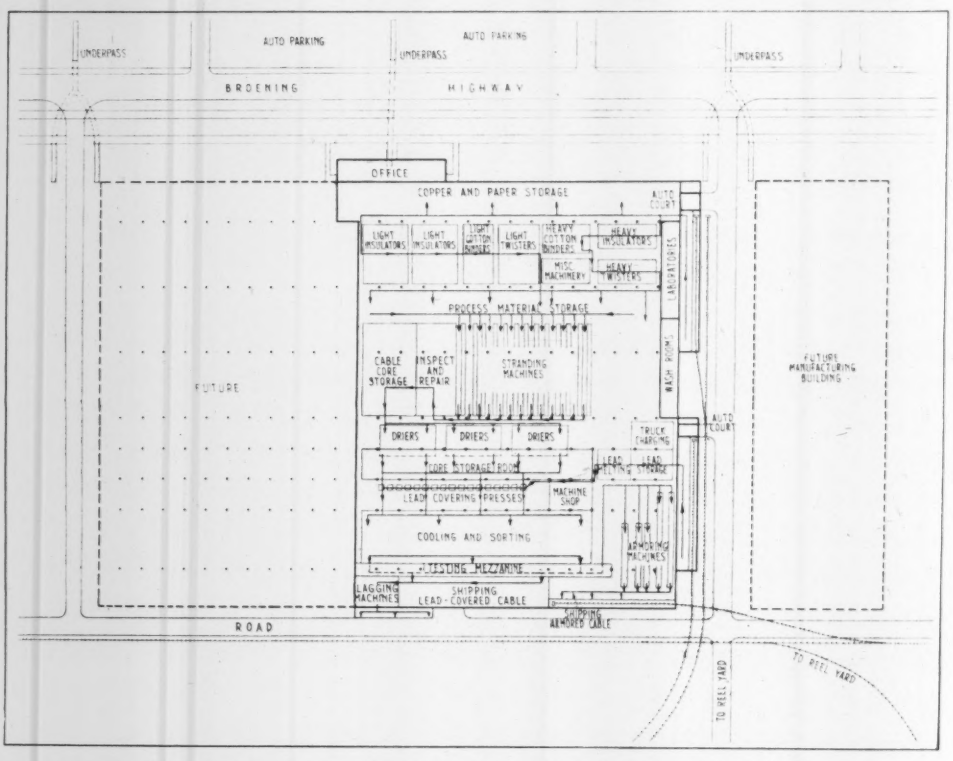

FIG. 2 LAYOUT OF TELEPHONE CABLE PLANT AT POINT BREEZE

In the first bay south of the raw-material bay are located the insulating, cotton-binding, and twisting machines. The insulating machines start the manufacturing operations. They are used to apply a spiral wrapping of paper on the copper cable conductors. The next machines in line are the cotton binders, which are used to measure the two wires of a pair to insure their being of equal length and to apply a spaced cotton binding to preserve the measured relationship of the two wires. The cotton-bound pairs are then placed in the twisting machines which are back-geared to give a twist to the pairs and also to twist two pairs at the same operation, producing a four-wire unit known as a "quad."

The cable manufactured in the Baltimore plant contains both light- and heavy-gage conductors, and it was therefore necessary to provide two groups of machinery. It will be noted by referring to Fig. 2 that the light-gage operations are started at the west end of the plant and the heavy gage at the east end. The insulating, cotton-binding, and twisting machines have been installed in long rows with supply and finished-product racks at the rear of the operators, the two supply racks of adjacent rows of machines flanking on aisles through which the electric trucks handling the supplies and the finished product move. This arrangement permits the truckers to deliver all supplies and to take away all finished product without in any way interfering with the machine operators. Following these initial operations the material in process moves again southward through the machines which strand the quads into cable cores, discharging the product at the south ends of the stranding machines.

As the cable core emerges from a stranding machine it is wound on a vertical steel drum mounted on a base

equipped with wheels to form a cable-core truck. These trucks are moved about by means of special electric lift trucks or picked up by an overhead bridge crane.

Fig. 5 shows the special truck designed to handle the core truck, and Fig. 6 the method of handling the trucks by means of an overhead crane. The top of the core truck is designed with a recess which engages a grappling device suspended from the crane hook, enabling the crane operator to pick up or deposit a core truck without the aid of a ground man.

When the required number of cables requiring similar drying treatment has accumulated, the overhead crane removes the loaded trucks from storage to a concentration area where electric lift trucks pick them up and deliver them to the vacuum driers which are horizontal welded steel-plate cylinders approximately 8 ft. in diameter and 40 ft. long, equipped with steam coils for raising the temperature.

FIG. 3 ELECTRIC-TRUCK METHOD OF HANDLING COPPER WIRE IN SKID BINS

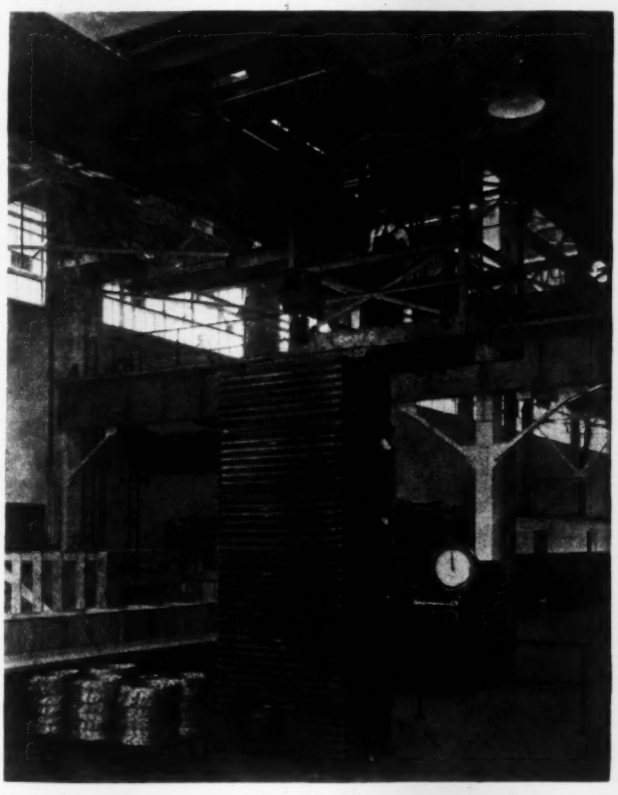

FIG. 4 CRANE STACKING OF CORRUGATED-STEEL SKID BINS IN STORAGE AREA

FIG. 5 LIFT TRUCK LOADING A VACUUM DRIER

FIG. 6 CRANE HANDLING OF NEW-TYPE CORE TRUCK

Each of the vacuum driers will accommodate eight or ten loaded trucks. Fig. 5 illustrates the method of charging cable cores into the driers. During the drying process practically all moisture is removed from the paper insulation, and if a satisfactory product is to be delivered it is essential that this dry condition be preserved throughout the remainder of the process.

The cables are removed from the driers by means of electric trucks of the same type as are used for loading (see Fig. 5), and the loaded cable trucks are stored in the enclosure pending the succeeding operation.

An interesting development in connection with the lead-covering process is the method of supplying lead to the covering presses. Briefly it consists of a battery of three large oil-fired kettles located adjacent to the lead-storage area. The metal mixture for covering the cables is made up in these melting furnaces and delivered to the presses in electrically heated pipe lines located at the rear of the lead presses (Fig. 7).

The motor-operated floor rolls, which rotate the reel

FIG. 7 LEAD PRESSES COVERING CABLE CORES

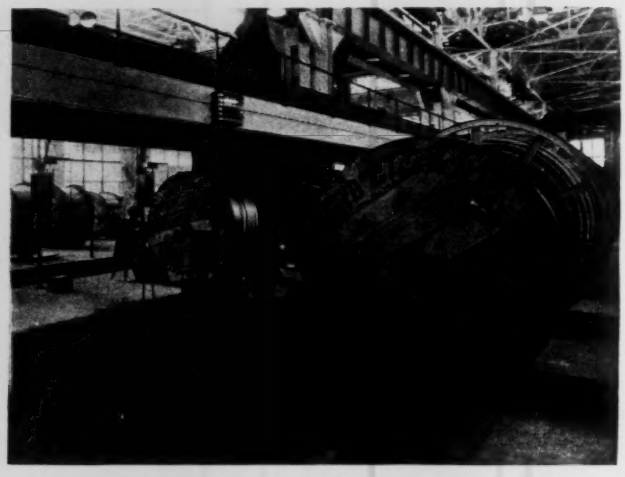

FIG. 8 FINAL INSPECTION OF LEAD-COVERED CABLE
(View shows floor roll, pedestal box, and floor-roll controller.)

on which the lead-covered cable is wound, are designed with a kick-off feature which pushes the reel forward on to the floor. The reel is now rolled southward into the next bay where it comes to rest in a shallow groove in the floor. From this location an overhead bridge crane picks up the reel by means of a grappling mechanism operated from the crane cab. This crane locates the cable reel in the cooling area, as the cables must be at room temperature before testing.

Fig. 8 shows the reels of cable on the test rolls with the test-set mezzanine above.

Fig. 9 shows the transfer car transporting a reel of cable from the inspection positions to the storage area prior to sealing. The reel is rolled forward from the transfer car on to the storage floor and placed in storage by means of another overhead crane equipped with a grappling mechanism. The cable reel is now transported by the same or a similar crane to a lagging machine (Fig. 10) where the wooden lags are placed around the periphery of the reel and secured in place with steel bands, following which the reel is rolled forward to a scale for weighing and then passed through doors in the south wall to an outside platform shielded from the weather by a canopy.

A steel shipping reel, recently developed and further improved lagging methods will displace the lagging machine for wood reels shown in Fig. 10. However, the savings due to the introduction of the lagging machine for wood reels more than paid for the machines, and the cost of their development.

The outside platform is equipped with a conveyor which can be moved in either direction to permit of selecting a vacant place along the platform where the

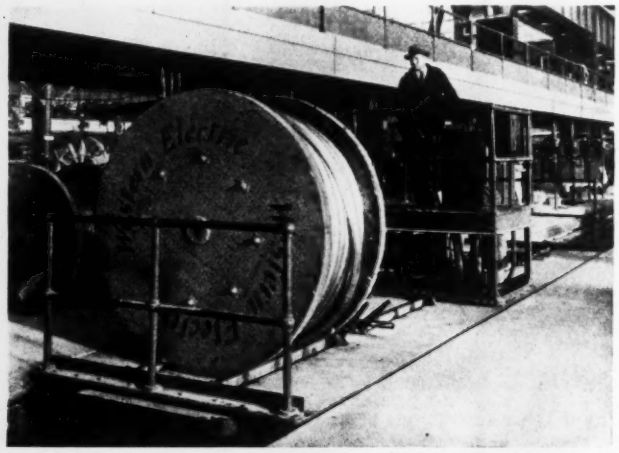

FIG. 9 CABLE-REEL TRANSFER CAR

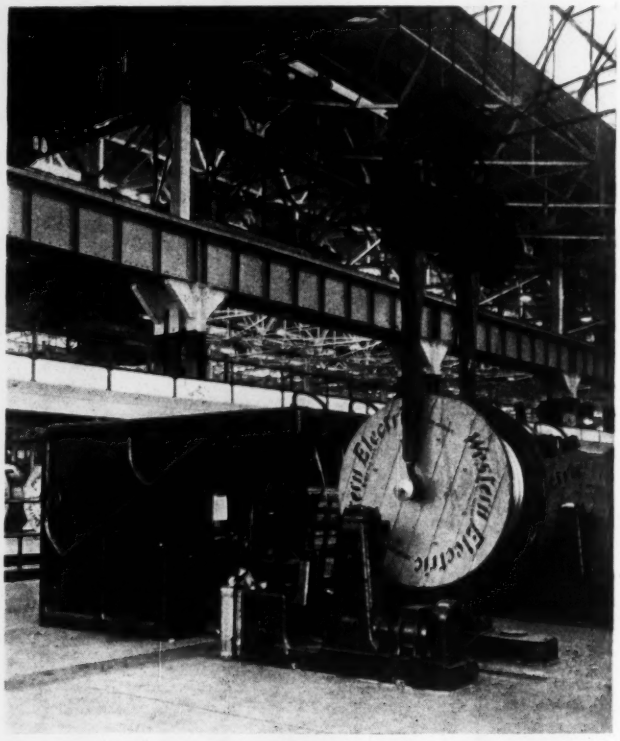

FIG. 10 CRANE PLACING REEL OF CABLE IN MACHINE FOR FASTENING WOODEN LAGS ON REELS

reel is placed awaiting transportation to the reel storage yard. The platform on which the cable rests is approximately 2 ft. higher than the roadway and the reel rolls forward onto the platform of a gasoline-engine-driven truck (Fig. 11). This truck removes the reels to the storage yard where they are deposited on small elevated platforms located along the roadway which runs the length of the storage yard. The truck is designed with a tilting feature which permits unloading the reel on the platforms in the reel yard from the truck cab.

If the reel of cable is to be shipped by water, one of the reel-yard bridge cranes places the reel on a special flat car which is shifted to a railroad siding along the bulkhead. The reel can be removed to a lighter or other vessel by means of a gantry crane spanning the siding. The gantry crane is equipped with a rotating boom and grappling mechanism for handling the reels of cable.

A portion of the plant output is shipped in the form of armored cable for either underground or underwater use. The underground type is armored with flat steel tapes, while the underwater type receives a much heavier armoring consisting of one or two layers of steel wire spiraled around the lead sheath. Two different types of machines are used for applying the armoring, both types being located at the east end of the area used for cooling cable after lead covering.

In the event that the armored cables are to be shipped by water, the reels are temporarily blocked on flat cars inside the building and the cars shifted to the armored-cable storage yard which is located along the bulkhead. In this area a stiff-leg derrick of 50 tons capacity at a 75-ft. radius has been installed to remove the cables from the flat cars to storage and later for loading on a barge or ship.

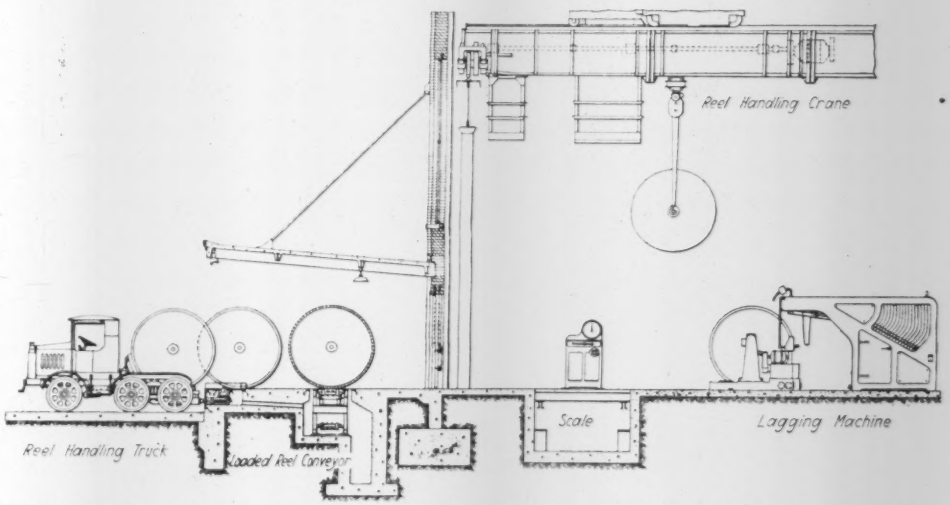

FIG. 11 SECTION THROUGH SHIPPING AREA SHOWING LAGGING MACHINE, CONVEYOR FOR MOVING REELS, AND REEL-HANDLING TRUCK

A bird's-eye view of the Point-Breeze Plant as it will appear when completed is shown in Fig. 12.

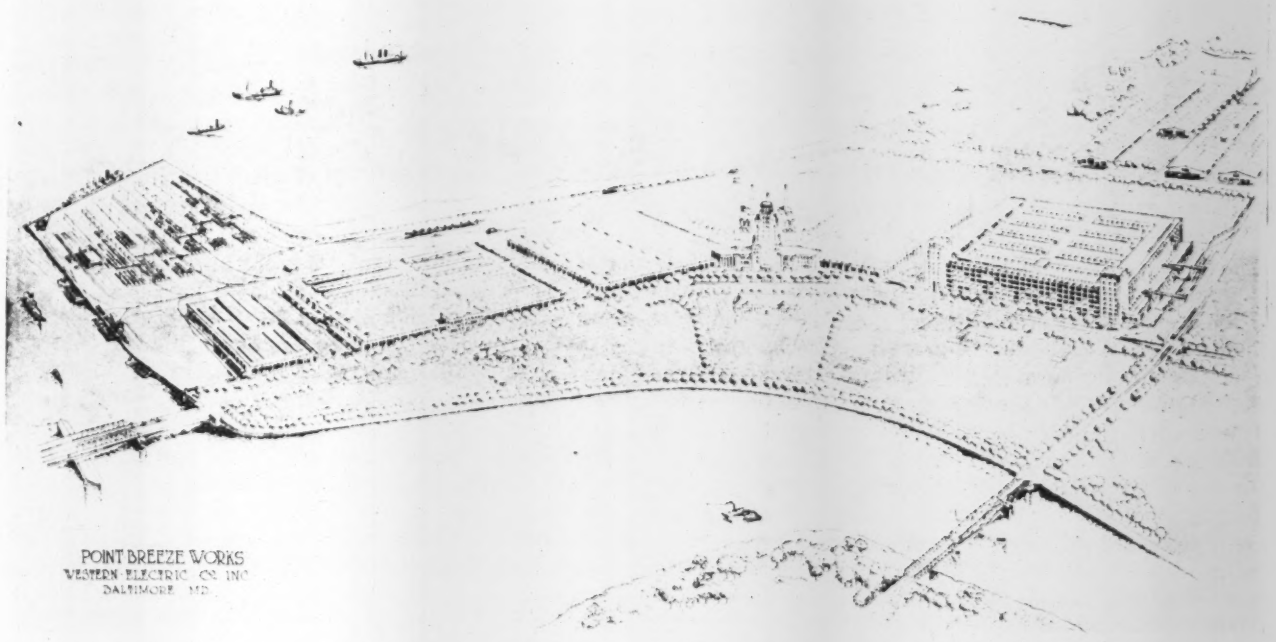

FIG. 12 BIRD'S-EYE VIEW OF POINT BREEZE WORKS AS IT WILL APPEAR WHEN COMPLETED
(Total area, 179.2 acres; total floor area, 4,821,291 sq. ft., of which 3,074,491 sq. ft. are in multi-storied buildings.)

New Methods of Rail Transportation

Proposed Methods of Transit at Speeds Around 100 Miles an Hour, Involving Such Features as Airscrew Propulsion and Cars Suspended From Tracks Traveling on Overhead Rails

A SYSTEM of rapid transit that has attracted considerable attention has recently been developed by George Bennie in England and has been tested on an experimental track built over the London & North Eastern Railway Company lines at Milngavie, near Glasgow. The car (Fig. 1) runs beneath an elevated track placed at a convenient height above the road or railway and supported by trestles at frequent intervals.[1] It is of light but rigid construction and is suspended by two laminated spring trucks from the upper rail and guided below by two sets of roller-bearing wheels. The drive is by specially designed tractor and pusher propellers, which may be operated either electrically or by an internal-combustion engine. As the car is not driven by adhesion but depends for propulsion solely on the airscrews, any variation in the tension of the laminated springs while the car is traveling at a given speed need not be detrimental to the drive. A system of hand and electrically controlled brakes is provided, the brakes gripping the rail top and bottom so that the wheels themselves run free when the car is decelerating. It is necessary to avoid the harmful effect of flat spots on the wheel surfaces and unequal wear rising from friction caused by surface braking.

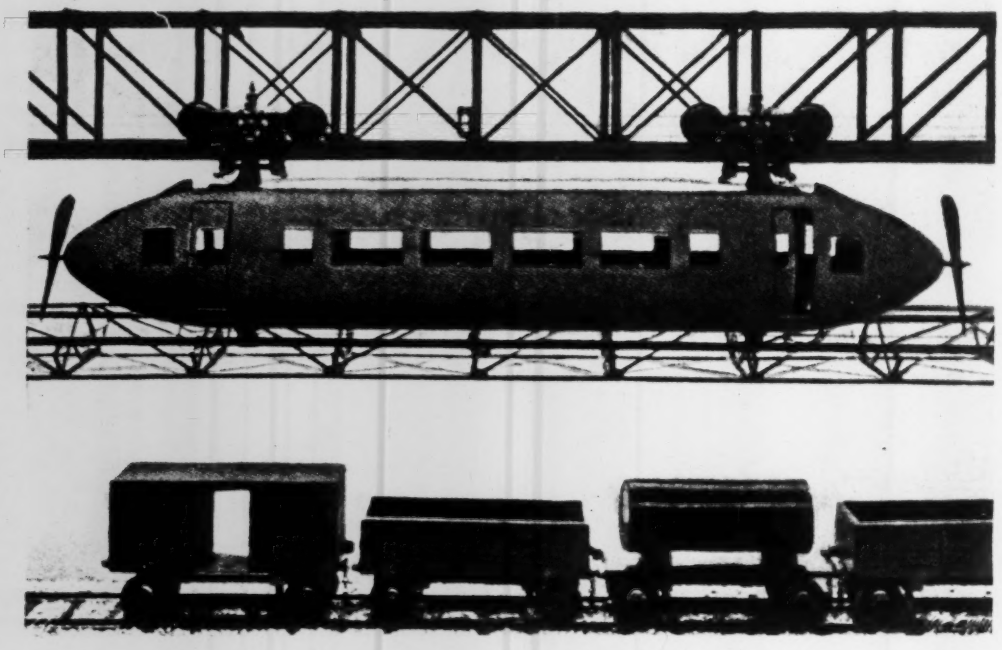

FIG. 1 THE BENNIE RAILPLANE RAILWAY

According to estimates published in *The Engineer* (August 23, 1929), a double-track railplane system can be constructed at from $85,000 to $95,000 per mile. The car itself is streamlined and is expected to run at very high speeds. It has been recently stated that the Blackpool Corporation has granted a contract for the construction of a railplane system and a highway bridge with which to connect the towns of Blackpool and Southport over the River Ribble. Other installations are under way in France.

THE "ZEPPELIN ON RAILS"

In Germany public tests have recently been made of a propeller-drive car running on a stretch of ordinary railway track. The development of this invention, according to a United States Commerce Report, is the work of two engineers, Franz Kruckenberg and Curt Stedefeld. The car itself was constructed by the Association for Technical Research in Transportation (Gesellschaft fuer Verkehrstechnik), which was founded in 1924 in Heidelberg. During the past few years the association has conducted exhaustive experiments with a view to developing more rapid means of transportation. Much assistance has been given this organization by the German State Railways, which placed a workshop and a stretch of track for experimental purposes at its disposal. The first trials were made with propeller-driven cars suspended from an overhead monorail. Considerable success was achieved in preliminary tests, but further development was hampered through lack of the necessary capital. The inventors then turned their attention toward the development of propeller-driven cars for operation on ordinary railway track.

The first tests were made in October, 1929, in the

[1] Another view of the Bennie railplane system will be found on the cover of this issue of MECHANICAL ENGINEERING.

vicinity of Hanover, on a stretch of track about five miles long between the towns of Burgwedel and Celle. These tests were fairly successful, but the experimental car was too light. It was therefore decided to construct a car of commercial size, and early in 1930 a coach 85 ft. long and weighing empty approximately 20 tons was built.

The first operating tests were made on August 15, 1930, and on September 23 high-speed trials were conducted with excellent success. A speed of 113 miles per hour was reached, and data collected indicate that much greater velocities could be attained over long distances. The starting acceleration of 0.63 m. (2 ft.) per sec. per sec. made it possible for the car to attain a speed of 100 km. (62 miles) per hour at the end of 66 sec. after covering a distance of 985 m. (3230 ft.). The fuel consumption at a speed of 150 km. (93.2 miles) per hour amounted 60 liters per 100 km. (0.255 gal. per mile).

Externally the new "Zeppelin on rails" resembles a rather low streamlined railway coach (Fig. 2). The frame is slung between the axles in order to keep the center of gravity as low as possible. The pusher-type 4-bladed propeller is located at the extreme rear of the car and is driven by a 500-hp. type-VI airplane engine manufactured by the Bayerische Motorenwerke. The engine-cooling system is located in the space under the propeller shaft, so that it is completely enclosed. The engine also drives an air compressor for the two independent brake systems provided, and two generators for charging a storage battery located in the forward end of the car. In addition to supplying current for lighting and ventilation, this battery also furnishes current for operating an electric motor for driving the coach when the airplane engine is not in use. This motor is used for starting and as an auxiliary source of power when running, and is connected to the front axle by bevel gears.

The frame of the car is of extremely rigid construction, and consists principally of steel tubing. In addition to spring suspension, the coach is further protected against shocks by rubber cushions set between the running gear and the car body. The connection between the trucks and the car body is so flexible that smooth running is assured even at high speeds, and in spite of its exceptionally long wheelbase—almost 20 m. ($65\frac{1}{2}$ ft.)—curves of as small a radius as 140 m. (459.3 ft.) present no difficulties.

An American Suspended-Monorail System

The scheme proposed in this country by the Atlantic Suspended Monorail Corporation and outlined by it at a meeting of the American Institute of the City of New York, December 13, 1930, is similar to those already mentioned in some ways, but is intended not so much for a major trunk-line development as it is for local service under special conditions. To all practical purposes the suspended monorail in question is a development of the elevated railroad found in many large cities in the United States, differing therefrom, however, in that the cars instead of running on the track, run beneath it. Advantages claimed for it are relatively low cost of construction and comparatively small power and maintenance requirements, together with smoothness and quietness in operation.

There is no question that the suspended-monorail railway will cost less than a subway. There can be little question as to the ability of engineers today to build such a railroad to operate safely and efficiently, as the Langen monorail line in Germany, which is of substantially the same type, has operated successfully for thirty years and carried several hundred thousand passengers.

The monorail car and the structure designed for American use are shown in Fig. 3. The trucks provide

FIG. 2 THE NEW "ZEPPELIN ON RAILS"

12 wheels per car, four of them being drivers, and they are so articulated that no more than two wheels are held rigidly in line. The proposed cars are of about the same size as those used in the New York subways, 64 ft. long and 9 ft. wide, to provide seats for 80, but the empty cars weigh 17 tons each as against 40 tons or more for the usual subway cars. This great difference is due partly to the use of aluminum instead of steel for the bodies, partly to lighter trucks and motors, and partly to the lower strength requirements of suspended cars.

In addition to the top rail carrying the cars, guide rails are to be provided to prevent them from swaying.

The proponents of this system claim that the suspended-monorail railway makes less noise than do our present elevated railways because the driving mechanism and wheels are above the car so that less noise is deflected downward by the car bodies.

ECONOMIC AND FINANCIAL COMPARISONS

In comparing from an economic point of view the German air-propeller surface coach and the Bennie railplane, the following factors should be borne in mind. In the first place, speed of transportation is not the only consideration. It does not appear to be clear from the data so far published whether the German propeller coach is expected to be operated as a single car or in trains, although the former case seems the more likely. If this is so, the cost of operation will be high. Each car will require at least one conductor and one motorman, and a motorman to whom fifty lives can be entrusted when his car is running at 100 m.p.h. or better will be an expensive man. Furthermore, operation by internal-combustion engines as compared with electric drive is expensive. The question of safety of operation at high speeds, particularly in America, is also an important one.

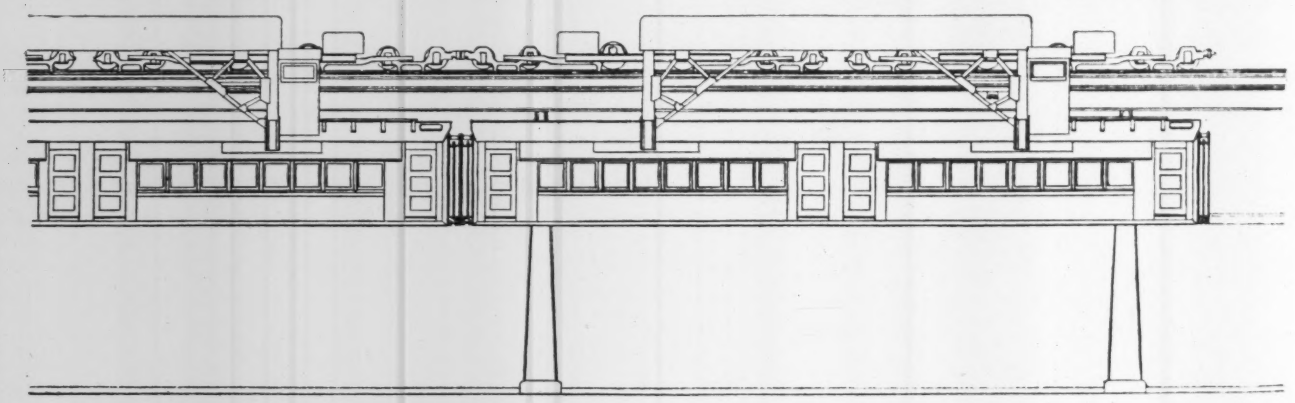

FIG. 3 PROPOSED SUSPENDED-MONORAIL RAILWAY OF AMERICAN DESIGN

From the financial point of view it must be borne in mind that replacement of existing passenger rolling stock with new cars of a radically different type, if carried out in a country of the size of the United States, even over a period of several years, would severely tax the resources and credit of the railway companies, particularly as it would have to be accompanied by a drastic write-down of the book value of the cars now in use. Whether this method of transportation would bring a sufficient increase in revenue, remains to be seen.

The Bennie system presents a somewhat different picture. The investment required is of course enormously greater than in the propeller-coach system. On the other hand, however, the Bennie system requires an overhead track, which means that there will be no grade crossings. What is more important, though, is the fact that while the railplane car in the Bennie system is suspended below the elevated track, there is nothing to prevent concreting the upper surface of the structure and using it for an automobile highway, probably on the toll principle. In this way the automobile would compete with the railroad as it does today, but it would also pay the railroad for the privilege of doing so. Such concessions as the sale of gasoline and supplies on the elevated highway would also be a source of revenue for the railroads. From this point of view the financing of the Bennie system, while involving very much larger amounts of capital, appears to be a less difficult matter than financing the reconstruction of passenger rolling stock. The fact that there is nothing whatever to prevent the operation of Bennie railplanes in trains is also an important advantage, as well as the fact that the system is eminently suitable for the application of electric drive.

John Blenkinsop, 1783-1831

THE centenary of the death of John Blenkinsop, whose name is associated with those of Trevithick, Hedley, and Stephenson as a pioneer of the steam locomotive and railway, occurred yesterday. Born in 1783, he died at the age of 47 and was buried at Rothwell Church, near Leeds, where his tomb is marked by a stone which says that he was for "upwards of twenty-three years steward of the Middleton Estate." Coal has been mined at Middleton for a very long time, and, in 1758, a wagonway had been laid down for its conveyance into Leeds. In 1800, the proprietors of Leeds Pottery, through whose works the wagonway ran, alone paid £2000 for coal, and it was the increasing traffic which led Blenkinsop, about a decade later, to lay down a cast-iron rack railway according to his patent of 1811. He employed Fenton, Murray, and Wood of Leeds to construct his engines, the design of which owed much to Matthew Murray. Each locomotive had two cylinders driving two cranks at right angles, and a large toothed wheel to engage in the rack on the outside groove of the rails. The line and engines were ready by the summer of 1812.

Within a year or two of the use of steam on the Middleton line, rack locomotives were at work at the Orrell Colliery, Wigan, and the Kenton and Coxlodge Collieries near Newcastle, and it was from these that Stephenson gained some of the ideas he used in the construction of his first locomotive.—*Engineering*, Jan. 23, 1931, p. 106.

The Boiler Room of the Future

A Conception Which Comprises a Gas-Fired Multicellular Boiler of the Tube-and-Header Type, Located With the Turbine, Generator, and Auxiliaries in the Same Room

By GEO. A. ORROK,[1] NEW YORK, N. Y.

I HAVE many times before this Society set forth the statistics of the production and use of mineral fuel in this country, and have commented on the large rate of increase in the use of such fuels in the last fifty years. In the paper on "Fuel Utilization" which was published in MECHANICAL ENGINEERING in April of last year, I gave the statistics at 10-year periods of the production and use of the various types of fuel, together with a tentative apportionment of the fuels among the various uses of industry. Roughly speaking, we use in this country the equivalent of 25×10^{15} British thermal units per annum, which includes the heat obtained from approximately 600,000,000 tons of solid fuels. Something over half of all our mineral fuel is fired in boilers for the making of steam under most diverse circumstances, running all the way from the small household boiler burning perhaps 8 tons of coal per annum, to the large East River boilers which may use up to 70 tons per hour at their maximum output. One of these boilers running at its average rating will use 40 tons of coal per hour, or approximately 290,000 tons of coal in a 300-day year. The variation in size is thus 1 to 36,000, and is representative of the range and the scope of this paper.

EARLY DEVELOPMENTS IN BOILERS

Before contemplating the future, it is always well to look back over the progress in the art and to consider the changes and improvements made in the generation of steam which have led up to the present-day attainments, and thus draw conclusions as to what may be expected in the future from the lessons of the past. We need not consider the teakettle boiler of Newcomen or the wagon-box boiler of Watt, except to note that these boilers were quite as rudimentary in character as the modern teakettle and consumed only "a few hundred-weight of coals" per day. The chimneys were short, the draft could hardly be measured on a water gage, and the steam pressures carried were of the order of those carried today in the modern cast-iron boiler of the small house-heating system.

The progress from a boiler plant of this type to the Cornish or Lancashire boilers in the England of the next generation or to the return tubular boiler which has been standard in America for small plants for many years, is exceedingly great. English practice followed the internally fired boiler type, and need not concern us here. But the return tubular type used in this country lent itself to excessive duplication, and the last generation saw many plants which consisted of possibly as many as 50 to 80, or even more, of these boilers, each about 66 in. in diameter and 18 ft. long, set in batteries of 2, 4, or 6, each boiler being provided with a grate possibly 5 ft. square and not more than 16 in. below the shell of the boiler, on which the fuel was burned. These boiler rooms were low and very dark, and the line of boilers usually had piles of ashes in front of the ash doors, while just behind each fireman was a pile of coal from which he fired his boiler. The coal and ash handling was done by wheelbarrows run by the fireman, and the firing of 250 lb. of coal per boiler per hour was a heavy task performed under the worst of conditions. It was conditions like these that led to the invention of the water-tube boiler, which lent itself much better to increasing size, and boilers of two to three times the capacity of the return tubulars soon became common, although the same disagreeable and laborious firing conditions continued for a long time. Within the last year I have been in certain boiler rooms where these same conditions still exist.

MODERN STEAM GENERATION

The demand for power in ever-increasing amounts soon forced the manufacturers to the enlargement of the water-tube boilers, which were readily susceptible to improvements in design. The increasing use of fuel led to the invention of mechanical stokers, and later to the firing of coal in powdered form, and boiler sizes and capacities have been increased up to the large units in the East River station which represent the last word up to date in capacity and fuel consumption per boiler. Meanwhile the working conditions for the firemen have improved. Windows have been introduced into the boiler room; mechanical stokers, fed from an overhead bunker with the coal automatically delivered into the stoker through a pipe, have lightened the labor of the fireman. Ash hoppers and

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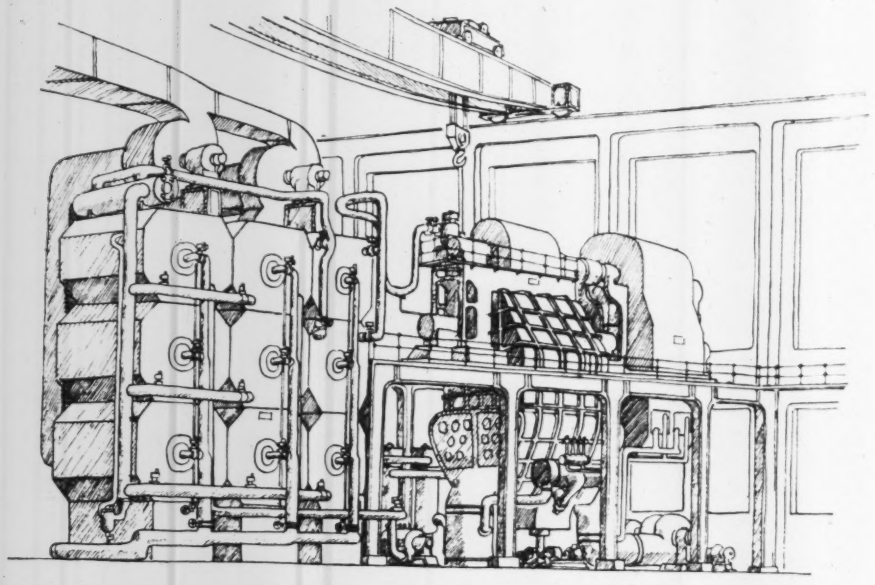
For presentation at the National Meeting of the A.S.M.E. Fuels Division, Chicago, Ill., February 10 to 13, 1931.

ash-disposal machinery have removed the ash pile from the boiler-room floor, and in many cases have eliminated the ash gang. Forced draft and the balanced-draft systems have ventilated and cleansed the atmosphere of the fire room, and from being the darkest, dingiest, dirtiest place in the power station, the boiler room is now open, airy, cool, and reasonably clean. The fireman, or rather the boiler operator, need not dirty his hands, and might easily wear a white shirt while at his work. Even the cost of making steam has been much reduced if the cost of the fuel itself is not taken into account.

But this is not all: the discovery of oil in Pennsylvania brought oil fuel into the boiler room, and we have today many boiler plants fired with oil which follow in general design those built for the use of solid fuel. With the production of oil, natural gas came into use, and good examples of boilers fired with natural gas are perhaps among the finest of present-day examples of the boiler-room art. With these improvements also came the control systems which have been designed to do away with the hand control of fire-room apparatus, and most of our modern plants are more or less automatically controlled with devices of this type.



The Boiler Room of the Future

("A boiler of this [multicellular] type would be self-contained with its auxiliaries, would make no dust or dirt, could be located in the same room as the turbine and generator, and the boiler room, as a boiler room, would disappear.")

The Boiler Room of Today

Taken in general, the boiler room of today is a reasonably clean, cool, comfortable building housing the entire steam-generating apparatus, with plenty of light for inspection, with an automatic control so that the boiler operator becomes practically an overseer whose duty it is to see that the various pieces of apparatus function in their normal manner, who only has real work to do in an emergency, and this whether the fuel be coal, oil, or gas. The coal passers and firemen have been superseded by machinery, the ash gang is non-existent, and the boiler-room operatives for a large plant might be cut down to one man as far as real labor is concerned. However, we have not yet been enabled to do away with the "black gang"—the boiler cleaners, who are still with us—because no matter how carefully machinery may be designed and built, at stated times it must be shut down, cleaned, and repaired for the next run. But even this job is not such a serious one where oil or gas is used as the fuel. I have been informed that there are instances of large boilers, oil or gas fired, which have not needed outside cleaning for a whole year at a time, and I know of a number of cases where the internal cleaning of boilers has been reduced to a washing out plus inspection. It is possible today so to treat most of our boiler waters as to give little cause for labor during the inspection period. We have examples of boilers which have run more than 20,000 hours without the loss of a tube, and required only very minor repairs at the end of the period.

Meanwhile boiler efficiency, or rather fuel efficiency, has been increased to a very large extent. In the early boilers not more than 50 per cent of the heat units in the fuel appeared in the steam at the boiler stop valve. Today, with our methods of heat saving and our modern designs, from 88 to 92 per cent is possible in a test; beyond this it has not yet appeared to be reasonable to attempt to go, although we know well that by means of heat exchangers we could probably increase this efficiency to perhaps 96 per cent, but at a cost too high to be considered.

One of the serious drawbacks to the earlier boilers was the fact that every once in a while one of them

would burst, spreading destruction around the neighborhood and usually resulting in serious loss of life. The boilers at that time were almost entirely of the shell type, with large diameters and reasonably thin iron plates, and were a constant menace unless great care was exercised in their construction and operation. However, progress in boiler design has cut down the size of shells or—as we now speak of them in the water-tube designs—drums, the thickness of the plates has been increased, steel has been substituted for iron, and today explosions of well-designed boilers practically never occur. In addition, we have certain designs of boilers for particularly high pressures in which there are no drums and in which the pressure fluid is confined in small tubes of very high strength as compared with the working pressure. Even should one of these tubes fracture, as it sometimes does, the possibility of damage is small indeed and has ceased to be a menace. Our metallurgists are working for the production of better tube and drum materials than those which we have for use at the present time, and there is no doubt that even these small dangers can soon be forgotten.

The foregoing paragraphs may serve to set forth the well-considered, efficient, and economically sound Boiler Room of Today, and we must now consider what the lessons of the past have taught us and what we may expect as a reasonable line of future development toward the Boiler Room of the Future.

SOLID FUELS

Our present use of fuel has been set at the equivalent of 25×10^{15} British thermal units per annum. Of this amount approximately 65 per cent represents the use of solid fuels, of which about one-seventh is anthracite coal. One of the serious drawbacks to the use of solid fuel lies in the ash content, and since many of the better deposits of coal in the United States have been exhausted, the ash content of the present supply varies roughly from 8 per cent in the best semi-bituminous coals to around 30 per cent in the fine sizes of anthracite, and much higher in lignites and other classes of coal now little used. The tonnage of ash is large, and its disposal has always been a serious problem. Wherever solid fuel is burned a substantial proportion of the ash is carried through the boiler, up the stack into the air, and scattered over the surrounding country. Roughly, where no dust catchers are used, it is probable that between 2 and 4 per cent of the weight of the coal fired is distributed in the vicinity of the plant as dust, and many experiments have been made to determine the dust fall in industrial communities. The reports of some of the smoke commissions in Great Britain show figures in excess of a thousand tons per square mile per year in certain cases, a most serious handicap to any locality.

Where the coal is burned in powdered form, the amount of dust escaping may be much larger, and even with the best of dust catchers a serious amount of fine dust, not larger than 25 microns in diameter, escapes into the air. Legislation in various countries has been directed against this nuisance, and particularly in England, where the latest law is quite drastic in its application to industrial furnaces. There are, however, methods of burning solid fuel and storing the heat units in gaseous form where none of the dust may escape into the atmosphere. These devices are well known and at the present time are quite satisfactory in operation, although their cost has been such as to prevent their extensive introduction. One of the results of this drastic legislation will be to make this type of apparatus for the burning of solid fuel much more attractive, and the use of complete gasification plants points one way to the solution of the boiler-house problem of the future.

GROWING USE OF LIQUID FUEL

The use of liquid fuel has been increasing to a remarkable degree, and at the present time 25 per cent of our yearly fuel supplies represents the use of mineral oil and its products in furnaces and internal-combustion engines. The remaining 8 to 10 per cent represents the use of natural gas, which is now distributed over a large portion of the country through pipe lines to the centers of use. This pipe-line network is being rapidly extended, and one firm alone is furnishing large-sized pipe at the rate of over 12,000 miles a year. It is estimated that more than 200,000 miles of pipe line 6 in. and larger in diameter are already in service, and whether our solid fuel will be gasified at the coal mine and transmitted to the point of use through pipe lines, or gasified at places far removed from thickly populated centers and piped shorter distances, is immaterial for this paper. But it would appear that in the near future the dust problem alone will necessitate the use of gaseous fuel for steam raising in the neighborhood of large centers of population. The gas companies well understand this problem, and there is hardly one in the country today which is not considering the making of such arrangements that houses may be heated with gas from their mains instead of with coal-fired furnaces with their attendant ash troubles, dirt in the cellar, and the expense and trouble of handling, storing, and firing the fuel. Installations of this type are being made daily in all of our larger cities at prices which make the householder eager to convert his coal-burning plant into an automatic gas-burning one.

Many of our central stations which have been burning powdered coal as a main source of supply, have their burning arrangements so made that oil may be used as the fuel when it is cheap enough, and many other plants are arranged for the burning of oil or natural gas in the same burner, depending on the cost of the fuel supply. The manifest advantages of fuel in the gaseous form, the ease of control, the cleanliness, the advantages of the mixing burner and combination burners, are already greatly appreciated.

Liquid fuel is a most convenient one for boiler-

room purposes. However, it would appear to be much too valuable a raw material to burn in its present form, particularly since there are at present 28,000,000 automobiles in the United States. The future will no doubt see a considerable increase in the number of automobiles and in the use of the distillation products of petroleum. Petroleum residues will probably always play quite a part in the generation of steam, but the boiler rooms in which they are utilized will not be ideal, and will only be a small proportion of the total number. I do not consider them as representative examples of the boiler room of the future.

Boilers of the Future Will Be Gas Fired

After what has been set forth in the last few paragraphs, we may postulate that the boilers of the future will be gas fired. This means that there need be no coal, no storage provisions, no coal-handling appliances. Ash will not be present and therefore dust catchers and the troubles incident to boiler cleaning may be forgotten. The fuel will be brought into the station through a pipe, and the products of combustion, largely carbonic acid and nitrogen, will go out of the chimney in a clean state. The atmosphere will not be polluted with dust, and the coal pile on a windy day will not scatter coal dust over the neighborhood. The householder will light his heating boiler in the fall, and, regulating it with a thermostat, he should not have occasion to be aware of its existence till he shuts it off the following spring.

In discussing this paper, one of my friends asked me why, when I had postulated gaseous fuel as the fuel of the future, I did not throw out the boiler plant and generate power with gas engines, thus getting rid of the entire boiler-house problem. I know perfectly well that the gas engine will be used to a certain extent—to how large an extent no one can say—but probably not widely, since its cost has never been brought down to the economical range. There is a field for the gasoline engine, the gas engine, and the Diesel engine, and these fields will be well covered, but the essential cheapness of steam machinery, its flexibility, together with the lack of limitation in size of apparatus, will, in my opinion, keep the steam boiler with us as long as heat engines continue to be our main source of power.

Boilers of the Future to Consist of Unit Cells of the Tube-and-Header Type

Having indicated the solution of the fuel problem, we must turn our attention to the apparatus, which is the boiler, since our subject is the boiler room of the future. We have today discarded the old forms of shell and fire-tube boilers and are coming more and more to a boiler which is a simple collection of tubes connected by headers of the same shape and of but little larger size. The laws of heat transfer are now fairly well known, and the advantages of a very rapid circulation on both the gas and water sides are thoroughly appreciated. We have at least six designs of boilers with exceedingly good characteristics which contain no large parts and which are truly safety boilers since a serious explosion of any of them is unthinkable. On many of these boilers the only sign that a break has taken place is the falling of steam pressure, which warns the operator that something has happened. The boiler of the future will be built along these lines. There will be no storage of steam in large shells, in fact we shall go back 100 years to the schemes of a Yankee inventor, Jacob Perkins, who believed in and patented the idea that steam should be made when it was wanted, and used immediately, thus making possible the use of any pressure within the thermodynamic range. Such boilers will naturally be very much smaller in size than many of the present-day boilers. With gaseous fuel and the preheating of combustion air, the flame can be made exceedingly short and the heat liberation may be quite large. The combustion space, which today is of considerable size, will be much reduced, and the speed of the products of combustion through the boiler will be very high in order that the heat transfer may also be high. I am inclined to believe that the boiler of the future might be termed a cellular boiler, in that it will be built up of a number of unit cells, each cell using a certain amount of fuel and generating a certain amount of steam, the number of cells in the boiler depending on the demand for steam. A boiler of this type would be self-contained with its auxiliaries, would make no dust or dirt, could be located in the same room as the turbine and generator, and the boiler room, as a boiler room, would disappear.

Conclusions

Summarizing, we may state the following conclusions as to the future.

I—All solid fuel for the making of heat and power in the future will be burned in the gaseous state, necessitating

- *a* Complete gasification plants
- *b* Coking plants where metallurgic applications are desired
- *c* A great development of pipe-line transportation for the distribution of fuel.

II—The development of large-capacity boilers of small physical size, using high speeds and high heat-transfer rates, necessitating

- *a* Excellent burner practice and low excess air
- *b* Absolute safety in boiler construction and design, very small water content, and no large drums
- *c* A high commercial efficiency since installation cost per unit of heat should be much lower.

III—The practical abolition of the smoke and dust nuisance from solid fuel in thickly settled communities.

Creep of Metals at Elevated Temperatures

Flow Under Stress at Elevated Temperatures—Probable Nature of Creep Phenomena—Various Forms of Creep Curves—Metallurgical Aspects—Significance of Creep to the Designer of Parts to Withstand High Temperatures

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IN THE field of design today many important advances are waiting only for the development of reliable metals which may be depended upon to carry relatively high working stresses at temperatures from 750 deg. fahr. to 1200 deg. fahr. In many cases suitable materials are now available, but it is necessary to choose the one best adapted to the particular application and to assign to it a safe working stress The latter requires consideration of corrosion and erosion which may reduce the cross-section of metal carrying the load, and metallurgical changes within the material which may change its physical properties during its life in service. To these must be added a generous allowance for the unfortunate fact that alloy steels suitable for high-temperature applications have a tendency toward non-uniformity. As a result, the specimens tested may not truly represent the material in the section where stresses are maximum. If failure requires actual rupture of the metal, the problem is often simplified, but if the allowable deformation within the expected service life of the material is extremely small, it is usually necessary to depend upon some form of long-time tension test or "creep" test to establish safe working stresses.

Definitions of Creep

In the past six or seven years the term "creep" has become quite familiar to all engineers. In its simplest form we may think of a vertical cylindrical rod supported at the top, carrying a constant load at the bottom, and heated to some constant high temperature over a definite portion of its length. If means are provided for measuring with great accuracy any change in length of the section in which stress and temperature are maintained constant, data may be obtained from which the usual creep curve can be plotted. Fig. 1 shows some of the forms which this curve may have, depending upon the material, the temperature, and the stress. The several types of curves will be discussed later.

From a consideration of this simple case, we may define creep as the plastic deformation or permanent set which results from the continued application of stress at elevated temperatures. The deformation during the application of the stress, which is usually a combination of elastic and plastic strain, is purposely excluded to simplify this discussion. The disadvantage of this definition is that it tells what creep *does* rather than what it *is*.

From the practical standpoint, creep tests must be limited in time, and much depends upon the extrapolation of curves to times equivalent to the expected life of the material in service. It is therefore of great importance to develop rational concepts of the fundamental nature of creep phenomena. It is extremely doubtful if a study of the deformation of a material under constant stress and temperature during a limited period of time is, in itself, a sound basis for predicting the deformation characteristics of the material up to the end of its life in service.

Returning to the thought of what creep actually is, we may quote a definition given by Bailey[2] which indicates that the problem is not simple. In Bailey's words: "Creep is the outward manifestation of the balance in the destruction of strain hardening by thermal influence and its recreation by further slip." On the surface this appears somewhat formidable, but it is essentially quite simple. It indicates primarily that creep is the net effect of two opposing forces, and this concept aids materially in the interpretation of the various forms of creep curves shown in Fig. 1.

Typical Creep Curves and Their Interpretation

Curve *A*, Fig. 1, represents a well-known case. During the readjustment of stresses in many structures, members may be temporarily overloaded, with the result that small plastic deformations occur. For

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Presented at the Western Metal Congress, San Francisco, Calif., February 16–21, 1931.

[2] R. W. Bailey, "Physical Properties of Metals and the Design of Plant for High-Temperature Service," North Western Branch, Institution of Mechanical Engineers, April 21, 1927. For abstract, see *Engineering*, vol. 124 (1927), p. 44.

example, this frequently happens during the construction of a bridge. If the amount of such deformation is small, no harm results. The deformation produces a small amount of cold work, which slightly increases the strength of the material and decreases its ductility. In some cases of overloading in service this deformation may be considerable. Within limits, the tendency is for the material to increase in strength to meet the increased load upon it, resulting in a time-deformation curve similar to *A* in which apparent stability of dimensions is reached. If the load is not further increased and if the strained metal is not exposed to elevated temperature, such stability may

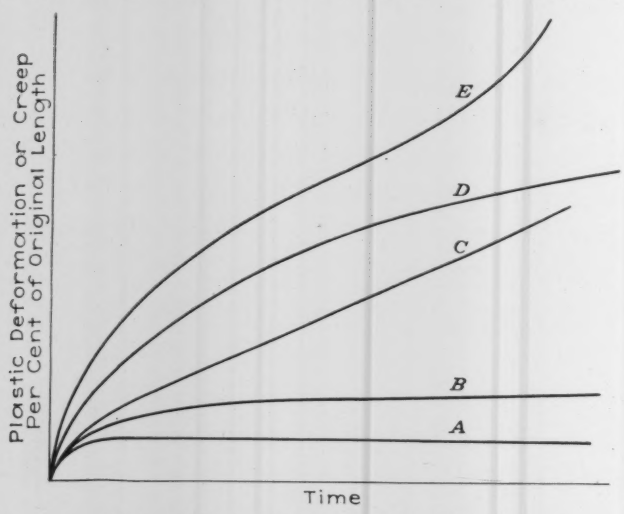

FIG. 1 VARIOUS FORMS OF CREEP CURVES

continue throughout the life of the part in service. If subsequent tests were made on this material in the same direction in which it was overstressed, it would be found to have higher strength and lower ductility than were obtained in the original inspection tests.

At elevated temperatures the problem is not so simple because exposure to elevated temperature tends to soften heat-treated or cold-worked metals. This leads to a condition represented by curve *B*. In this case the change of slope of the curve is more gradual, and a creep test may be prolonged for many months without assurance that stability has been reached. This is particularly true if the test apparatus allows very sensitive measurement of deformation and if creep is not masked by length changes due to temperature fluctuations during the test. The conduct of creep tests without the utmost precision of measurement and temperature control tends to give curves of form *A* instead of *B*. The danger involved in reporting tests indicating a stability which does not exist is often not fully appreciated.

Curve *C* represents the so-called first and second stages of creep. In the first stage the slope of the curve gradually diminishes, and this is followed by flow at a constant rate during the second stage. This form of curve has been used more than any other in published creep results, and much significance is placed upon the slope of the curve in the second stage of "creep rate." If we look upon creep as a net effect of strain hardening and annealing, this is seen to be a special case in which the relation between the two opposing forces remains constant over a long period of time.

Curve *D* is one frequently obtained in practice. It is like curve *B* in form, but the plastic deformation is greater. In spite of the gradually diminishing creep rate, it is usually conceded that stability will not be reached with this type of curve.

Curve *E* represents the condition of high stress or high temperature, or both. The stage of increasing creep rate or third stage usually begins with "necking" of the test specimen and ends in failure. The inflection in this curve is easily explained on the basis of stress changes. With a few exceptions, of which the work of Cournot and Sasagawa[3] is an example, all tensile creep tests in which the load is constant are assumed to have also a constant stress. As the test specimen extends, however, the cross-section diminishes and the unit stress increases. With relatively high stress or temperature or both, the total plastic deformation becomes large, and the error in assuming constant stress can no longer be ignored. When a creep curve shows this inflection, fracture is inevitable since the rate of flow increases to failure.

These curves indicate the value of Bailey's definition of creep. The various forms are easily explained by the concept of two opposing forces, one of which tends to decrease and the other to increase the creep rate.

METALLURGICAL SIGNIFICANCE OF CREEP PHENOMENA

From the foregoing, it is evident that any prediction of the total creep within a time representing the service life of the metal requires a thorough understanding of the metallurgical changes which may result from long exposure to stress at elevated temperatures. Even a casual study of this phase of the subject indicates the enormous influence which grain growth and softening will have upon creep phenomena.

Let us consider for a moment the internal structure of our metals. The microscope reveals crystals having random orientation, between which is found an intercrystalline material which may be either a so-called "amorphous cement," or possibly finer crystals which are too small to be resolved by present-day microscopes. The amorphous-cement theories of Beilby and Rosenhain may have to give way to the small-crystal concept as a result of X-ray investigation of this subject.

If a specimen is stretched at normal temperature, we know that plastic deformation results from slip along crystallographic planes which coincide with planes of maximum shear least favorably situated with respect to the principal stress. According to the slip-

[3] J. Cournot and K. Sasagawa, "The Investigation of the Viscosity of Alloys at High Temperature," *Revue de Métallurgie*, vol. 22 (1925), no. 12, p. 753.

interference theory of Jeffries and Archer,[4] slip is opposed at the grain boundaries, with the result that metals increase in strength as the grain size diminishes. Going in the other direction, single crystals are notably weak, but their loss in strength is somewhat compensated by a gain in ductility.

The slip-interference theory thus accounts for the fact that metals at normal temperature are strengthened by treatments which reduce the grain size. At elevated temperatures, however, there is now some evidence that metals are weakened by reducing the grain size. This may be due to the relative volume of material within and between the crystals. Carried to the extreme case, we should expect single crystals to have high resistance to creep. Experiments in this direction are now in process.

Regardless of the size of crystals, fracture at normal temperatures is generally intracrystalline. At high temperatures, on the other hand, we frequently find intercrystalline fractures. This leads to the idea of an "equicohesive" temperature at which the crystals and the material between them have the same strength. Theoretically, fracture will occur through the crystals themselves below this temperature, and between the crystals above this temperature.

In the present state of our knowledge, it is impossible to say whether creep is due to slip within the crystals, to plastic flow of the intercrystalline material, or to a combination of the two. Tests at normal temperature tend to support the first view, tests at very high temperatures the second, and a large number of intermediate tests appear to fall in the third class. Furthermore the location of the equicohesive temperature itself is uncertain, and appears to be very much influenced by the past history of the material. It is therefore quite possible that the laws which appear to govern creep phenomena during relatively short tests may change appreciably after long exposure to high temperature and stress. Since such changes are possible, great care must be used in the extrapolation of creep curves.

So far we have considered only the cold work due to creep itself, and the subsequent removal of this strain hardening by thermal influence. We may have in addition the effects of previous cold work such as rolling below the critical temperature or any other treatment which leaves internal stresses in the metal. In general, the greater the amount of cold work, the lower will be the temperature which will cause softening, or the shorter will be the time required to produce softening at a given temperature. The work of Pilling and Halliwell[5] and others throws considerable light on these phenomena.

Heat-treated materials also have a tendency to be unstable if subjected to long exposure to stress at elevated temperature. It is often claimed that a material which has been quenched and drawn may be exposed to any temperature below the drawing temperature for any length of time without further softening. Experiments show that this is not true, and the stability of heat-treated as well as cold-worked materials at high temperatures is open to considerable doubt. In many cases the time required is extremely long, but the study of thermal effects must give due consideration to the time of exposure to the high temperature.

Another metallurgical change which has a great influence on creep tests is the age hardening of certain alloys. This may not only reduce the creep rate to zero, but actually cause contraction of the test specimen. This phenomenon is due to precipitation of certain constituents, accompanied by increase in strength and decrease in ductility. However, the added strength from this change approaches a maximum, after which further exposure to elevated temperature results in a decrease of strength. Alloys in this class might easily show stability during a long period of test, after which creep would start and proceed at an increasing rate.

Significance of Creep to the Designer

The designer may well say that he is not interested in all the metallurgical details which may influence creep. The answer is that the success or failure of his design may hinge upon the attention paid to these same details. It is the duty of the designer to decide upon a safe working stress, and it has been shown that his choice must be based not only upon tests of the material involved but also upon a wide knowledge of materials under various service conditions.

In the early days of design it was sufficient to know the tensile strength of the material, and all other considerations were covered by a generous factor of safety. At that time the choice of materials was very limited, and service requirements were relatively easy to meet. As our knowledge increased and better materials became available, working stresses were raised to meet the demand for lighter, stronger parts. The element of cost cannot be ignored, and a more expensive material may be economically justified if it will carry a higher working stress. This again emphasizes the importance of a rational choice of working stresses.

When creep tests were first made, the idea prevailed that there was a determinable "creep limit stress" for a given material at any temperature. It was assumed that stresses above this limit would result in continuous plastic deformation, while below this limit stability of dimensions might be expected. To a certain extent this idea still exists, and we find a demand for creep limits which will yield safe working stresses upon application of a suitable factor of safety. Unfortunately, the bulk of experimental evidence indicates that real creep limits do not exist. The tendency is to design on the basis of maximum allowable deformation, and this requires the reliable determination

[4] Z. Jeffries and R. S. Archer, "The Slip Interference Theory of the Hardening of Metals," *Chemical & Metallurgical Engineering*, June 15, 1921.

[5] N. B. Pilling and G. P. Halliwell, "Softening of Hard-Rolled Electrolytic Copper," Proc. A.S.T.M., vol. 25 (1925), part II, p. 97.

of creep rates by carefully conducted tests. Since practical considerations limit the length of such tests, extrapolation of creep curves is necessary. It should be remembered, however, that many factors affect such extrapolation in addition to the length of straight edge available. It behooves the designer to adopt a critical attitude toward extravagant claims for the large number of alloys now on the market. It is quite possible that our greatest need is for more knowledge of present metals rather than for a marvelous material with properties exceeding our greatest expectations.

To a certain extent the designer is at the mercy of the metallurgist, as so much depends upon the treatment of the metal in making it ready for service. Also, the tendency toward non-uniformity previously mentioned is worthy of careful consideration by the producers of alloy steels. It sometimes happens that two test specimens which are supposedly identical show wide differences in properties. If more careful preparation of alloys can remove such conditions and the resultant uncertainty as to the accuracy of test results, it will be an accomplishment of real practical value.

Conclusions

It is not the purpose of this paper to disparage any of the excellent testing work which has been and is being done. The author has been making long-time or creep tests for the past six years, and he fully appreciates the importance of such tests. It seems desirable, however, to bring home to mechanical engineers in general and to those engaged in design for high-temperature service in particular, the importance of a thorough knowledge of the action of various materials under the combined influence of stress, temperature, and time. The collection of reliable creep data for the numerous metals and alloys now available will require many years. In the meantime it is probable that extensive service applications will be made without having complete data on creep phenomena. These are, in themselves, the best kind of tests if accurate records are kept, and it is hoped that all such data will be carefully preserved and published. The extent of the problem is so great and its importance so apparent that it merits the best efforts of mechanical and metallurgical engineers, and the close cooperation of those in the field with the most intimate knowledge of service conditions and performance.

The Divinity Surrounding the Work of the Engineer

SO FAR as I know there has never been a god of engineering, nor a goddess. The pagan gods and goddesses were all banished before the science of engineering came into being. It has been built up into the wonderful thing it now is without any assistance from the divinities or the patron saints of steel and iron. If one wanted an example of a purely secular calling that needs no god to help it along, one might pitch on engineering as just the example required.

But engineering is not such a secular thing as it looks. All that I can learn about the earth and the solar system and the other members of the astronomical universe suggests to me that the mind which operates in those stupendous arrangements has points of contact and resemblance with the mind of the engineer. It is certainly a mind that operates, and not a mind that merely looks on, and it operates in a manner which is reflected on a small scale in the triumphs of engineering skill. I cannot agree with those people who tell us there is nothing mechanical in nature. There is much else besides mechanism, of course, but if there were no mechanism at all the stars would drop out of the sky.

On that ground may we not say divinity surrounds the work of the engineer? It is divine work, carried out on the human scale. God, who is Himself so wonderful an engineer (Sir James Jeans suggests that He is a mathematician), takes an interest in it not less than He takes in the work of a clergyman, a philosopher or a theologian. It is a mistake to think the God attends only to the prayers we say or the sermons we preach or the creed we profess; He attends also to the bridges that we build, to the machines that we put together, and to the material we put into them. He demands that all of it shall be the very best that skill and competence can devise. I have no doubt at all that a well-built bridge or a well-constructed marine engine is an act of homage paid to God, and not less acceptable to Him than the most eloquent prayer or sermon that was ever uttered.

The old pagan blacksmith who said his prayer to the god of the forge and believed that his god followed the same trade as himself was feeling after a mighty truth. The good workman is a godlike person, and the work that he turns out resembles the work of God.

There is much big talk in these days about "spiritualizing society;" but nobody seems to know how it is to be done. It will certainly not be done merely by talking about it. How can you spiritualize engineering? How can you spiritualize bridge building? The answer is really very simple. You spiritualize your work by doing it in the best manner that it admits of. The spiritual is only another name for the very best—not something opposed to the material, but simply the material made the best of. Build the best bridge possible and you have done all that humanly can be done to make the building of it spiritual and to spiritualize yourself as the builder.—Prof. L. P. Jacks, Editor of *The Hibbert Journal*, in *The New York Times Magazine*, Jan. 25, 1931, pp. 3 and 22.

European Laboratories for the Testing of Materials

Observations Covering the More Important British and Continental University and Industrial Laboratories Devoted Principally to Research in the Mechanics of Materials

By FRANKLIN L. EVERETT,[1] ANN ARBOR, MICH.

SEVERAL months ago the author made a trip to Europe for the purpose of visiting a number of the more important university and industrial engineering laboratories interested principally in mechanics. Some fourteen of these laboratories, in Germany, Switzerland, England, and Sweden, were seen which are conducting work of a high type, and we who are connected with or even only indirectly interested in research work in the United States should welcome opportunities for better contact with them.

It is proposed to record here some impressions and general information regarding the laboratories which were visited with the view of helping to acquaint other American engineers with the conditions under which research is conducted abroad.

Contrary to the general belief, industries operating on a large scale are not uncommon in Europe, and in these, fine design and workmanship in manufactured products are held of the first importance. Large sums of money are invested annually in research both in the United States and in Europe, but for pure research Europe expends more than the United States.

German Laboratories

In Berlin the Siemens-Schuckert Works maintains a fine example of an industrial research laboratory. About two hundred—mostly college graduates—are employed in this laboratory, of whom some fifty hold the advanced degree of doctor. There are three departments: steel testing, physics, and chemistry, all of which are doing research work of a fundamental character. In mechanics, experiments in dynamics are being carried on dealing with impact and fatigue, as well as static tests with the usual tension-compression-bending equipment.

The research laboratories of the German Federal Railroads, under the direction of M. Füchsell, are located in Berlin.

Dr. Ing. R. Bernhard[2,3] consultant for the Federal Railroads, has carried out several searching investigations on both electric-welded and riveted-type bridges by employing a machine for producing dynamic loading developed by Dr. W. Spath of the Losenhausenwerk, Düsseldorf.[4,5] The apparatus consists of a small steel railroad car which can be taken to the bridge to be tested. Fig. 1 shows a machine which is capable of producing vertical dynamic loading in place on a bridge during a test. The car is equipped with several electrically driven rotating masses, as seen in the schematic drawing of Fig. 2, which may be adjusted to produce centrifugal forces of various magnitudes. With the latest type of machine, impulses in directions vertical, longitudinal, and lateral can be imparted to the bridge at any desired speed. By the use of a vibrograph the natural frequency of the bridge may be determined, and also the frequency of the system when loaded with a locomotive and train of cars. The electrical power required to drive the dynamic machine is also measured, and when plotted also indicates by a maximum point the natural frequency of the system.

At the grounds of the laboratory full-size models similar to the bridges to be used in actual future installations are studied. Tests to destruction are carried out on some structures by the use of a dynamic loading machine similar to the one described above but with much heavier rotating masses. The final structure for use in the field is tested after completion, and the program calls for subsequent periodic tests to check the condition of the bridge after it has been in service. Fig. 3 shows the characteristic frequency curves obtained for a particular bridge under two conditions. The upper curve indicates the power required at various

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[2] R. Bernhard, "Dauerversuche an genieteten und geschweissten Brücke," *Z.V.D.I.*, Bd., 73 (1929), Nr. 47. Also, *Engineering News-Record*, July 26, 1928.

[3] R. Bernhard, "Die erste geschweiste Eisenbahnfachweilbrücke," *Der Stahlbau* (Bautechnik), Bd. 1 (1928), s. 207.

[4] R. Bernhard u. W. Späth, "Rein dynamische Verfahren zum Untersuchung den Beanspruchungen von Bauwerken," *Der Stahlbau* (Bautechnik), 1929, Heft 6.

[5] W. Späth, "Dynamische Untersuchungen an technischen Gebilden," *Z.V.D.I.*, Bd. 73 (1929), Nr. 27.

speeds by the dynamic machine on an unloaded bridge, while the lower one is obtained when the bridge is loaded by a locomotive. The natural frequency in each instance is readily observed as the maximum point of the curve. Recently methods of X-ray analysis of welded construction have been adopted to study conditions in the field. A railway car has been provided with

FIG. 1 MACHINE FOR APPLYING DYNAMIC LOADING TO A BRIDGE

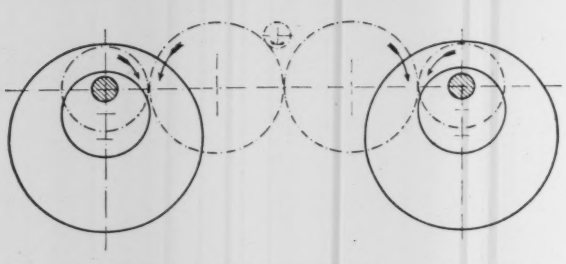

FIG. 2 ARRANGEMENT OF ROTATING MASSES ON TEST CAR SHOWN IN FIG. 1

suitable equipment and is taken to the bridge which is to be examined.[6] The dynamic machine has also been successfully used for producing vibrations in ships in order to determine their natural frequency.[7]

Other research problems in impact fatigue and rolling friction are receiving careful study. These are of a more fundamental character.

The State Materials Testing Laboratory, at Berlin-Dahlem, directed by Dr. Ing. K. Memmler, is one of the largest institutions of its kind. It was organized by A. Martens about thirty years ago. One of the important problems now being investigated concerns riveted construction, in which work a huge 1500-ton tension, 3000-ton compression machine is being employed.

Fundamental problems in the fatigue of various metals are also receiving attention from Dr. K. Laute. A tension-compression machine[8] of a very high frequency (500 reversals per second) is used which produces fracture in a much shorter time than the ordinary machine.

At the Kaiser Wilhelm Institute for Metal Research, also at Berlin-Dahlem, Dr. Ing. G. Sachs is developing methods of X-ray analysis of welded joints and of other material to locate defects.

A test method for determining the drawing qualities of various metals is also being developed under the supervision of Dr. Sachs.[9] The common test of this kind, devised by Erichsen, employs a circular plate of the specimen material. This is pressed by suitable dies into the form of cup. The new test which is being studied consists of drawing a wedge-shaped specimen of the material under investigation through

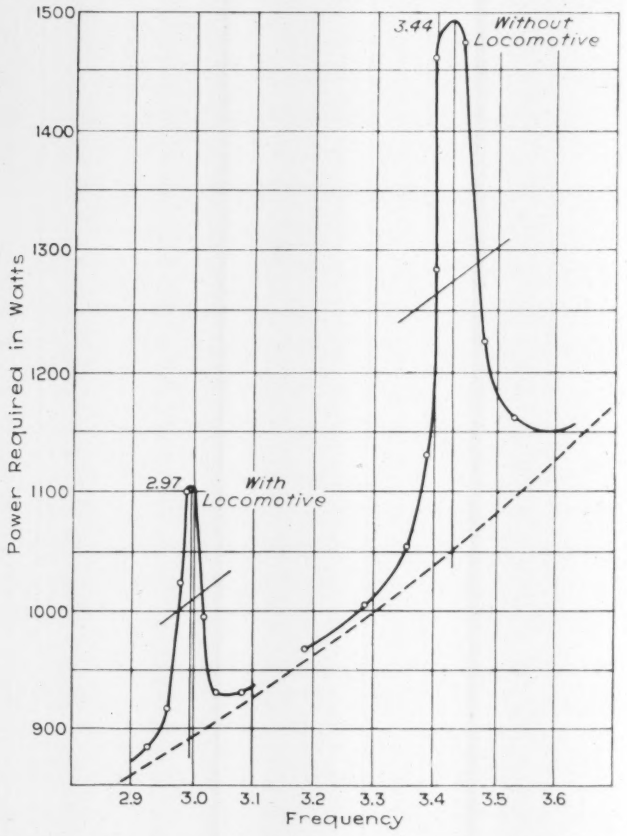

FIG. 3 CHARACTERISTIC FREQUENCY CURVES FOR LOADEL AND UNLOADED BRIDGE (VLOTHO BRIDGE, 233 FT. LONG)

a suitable die block. This is accomplished in the usual tension testing machine.

The Polytechnic Institute in Dresden is well equipped with apparatus for material testing. The largest vertical bending and compression machine in Germany, of 1000 tons capacity, was designed and is located here. Various types of tests are being made under Prof. K.

[6] R. Bernhard, "Neuere geschweisste Brücken," *Z.V.D.I.*, Bd. 74 (1930), Nr. 35, s. 1201–1207.

[7] W. Späth, "Dynamische Untersuchungen an Schiffen," *Werft-Reederei-Hafen*, Bd. 11 (1930), Heft 5.

[8] K. Memmler u. K. Laute, "Dauerversuche an der Hochfrequenz-Zug-Druck Maschine," Forschungsarbeiten auf dem Gebiete des Ingenieurwesens. Heft 329 (1930).

[9] G. Sachs, "Ein neues Prüfgerät für Tiefziehbleche," *Metallwirtschaft*, Bd. 9, Nr. 10, March 7, 1930, s. 213–218.

Kutzbach on belting, with ingenious special apparatus. Some very interesting work has recently been done on aluminum under impact at various temperatures ranging roughly from —200 deg. cent. to +200 deg. cent.[10] High-temperature "creep" tests of steels are in progress under Prof. Dr. Ing. W. Gehler, director of research and material testing.

One of the largest materials-testing laboratories is that of the Polytechnic Institute in Munich, headed by Dr. Ing. L. Föppl. It was founded by J. Bauschinger, the father of modern developments in testing materials. August Föppl, a well-known authority on mechanics, has succeeded Bauschinger in this laboratory. Fatigue of metals in torsion is being studied. Impact tests are being carried out on stone and concrete specimens. The photoelastic apparatus now employed in many research laboratories in the solution of stress-analysis problems is utilized in many experiments here.

The Kaiser Wilhelm Institute for Steel Research at Düsseldorf is engaged in many interesting programs dealing with the testing of steel. Particularly important at the moment are their tests in fatigue and creep, both conducted at high temperatures.[11] This laboratory has fortunate connections with the steel industry of Germany, from which it receives support. There are perhaps thirty units of the Institute scattered throughout Germany, each specializing in some particular phase of research.

The Losenhausen Works, which manufactures testing machines of all descriptions, is also located at Düsseldorf. At the present time it is devoting much attention to the production of balancing machines for use in the elimination of vibrations. Dr. W. Spath has developed a very promising machine[12] for use on rotating parts such as automobile crankshafts, rotors, and turbine disks. It employs a magnetic scheme to apply forces to the revolving piece under examination. The magnitude and angular position of these forces are adjusted until the vibration is a minimum, and the necessary counterbalancing weights and their required location are indicated directly on dials on an instrument board.

As a result of the comparatively recent interest in fatigue of metals, the Losenhausen Works has developed a highly important machine for torsion tests. In this the oscillating motion is effected by electrical equipment, and torsional deformations are measured optically with precision. Fig. 4 shows a torsion fatigue machine which is representative of the recent designs of this company.

SWISS LABORATORIES

The Polytechnic Institute of Zurich, Switzerland, possesses one of the finest existing laboratories for research in mechanics. In addition to being used for teaching purposes and graduate work, it is also the Swiss Government testing laboratory. Some very interesting work is in progress on creep of metals at high temperatures and on fatigue in bending. Repeated-impact tests are being made, and sliding friction and wear between rolling parts is receiving attention. This latter is a vital problem for railroads. The laboratory is very adequately supplied with apparatus and ably equipped in personnel, so that it conducts research work of a high type. Here Huggenberger tensometers are frequently employed and have proved

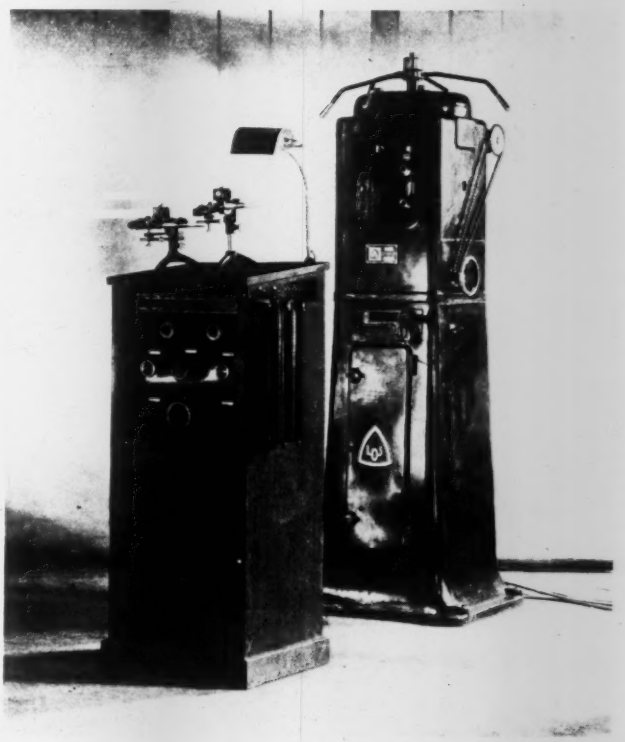

FIG. 4 LOSENHAUSEN TORSION FATIGUE-TESTING MACHINE

exceedingly useful in the exact measurement of strain. These instruments are capable of a magnification of 1200 and read to an accuracy of $^1/_{100.000}$ of an inch.

The Amsler Works, at Schaffhausen, Switzerland, produces all types of materials-testing equipment of good design and fine workmanship. Its machines enjoy a very high reputation in Europe, and it is hoped that their application will become more general in the United States.

The hydraulic-type machine shown in Fig. 5 is an Amsler product. Advantages over the usual lever type are the speed with which it indicates the true load and its automatic registration of the magnitude of the load at all times up to breaking of the specimen.

BRITISH LABORATORIES

Three laboratories were visited in England. The Engineering and Metallurgy Department of the National Physical Laboratory at Teddington, near London,

[10] Schwimming u. Fischer, *Zeit. für Metallkunde*, Jan., 1930.

[11] A. Pomp u. W. Enders, "Zur Bestimmung der Dauerfestigkeit im Abkürzungsverfahren," Mitt. a.d.K.W.I.f. Eisenforschung zu Düsseldorf, Ab. 152, 1930.

[12] W. Späth, "Die Auswuchtung rotierenden Apparateleile, *Elek. Zeit.*, Heft 3 (1930), s. 86.

is engaged in an elaborate program of work on the fatigue of metals and on creep at high temperatures. The work on fatigue of metals is being supervised by Dr. H. J. Gough, and the high-temperature creep investigations by H. J. Tapsell. Probably more work along these lines is in progress here than at any other one place in the world.

Bending and direct tension-compression fatigue are being studied as well as torsion fatigue. Work is in progress on the fatigue of single crystals of metals

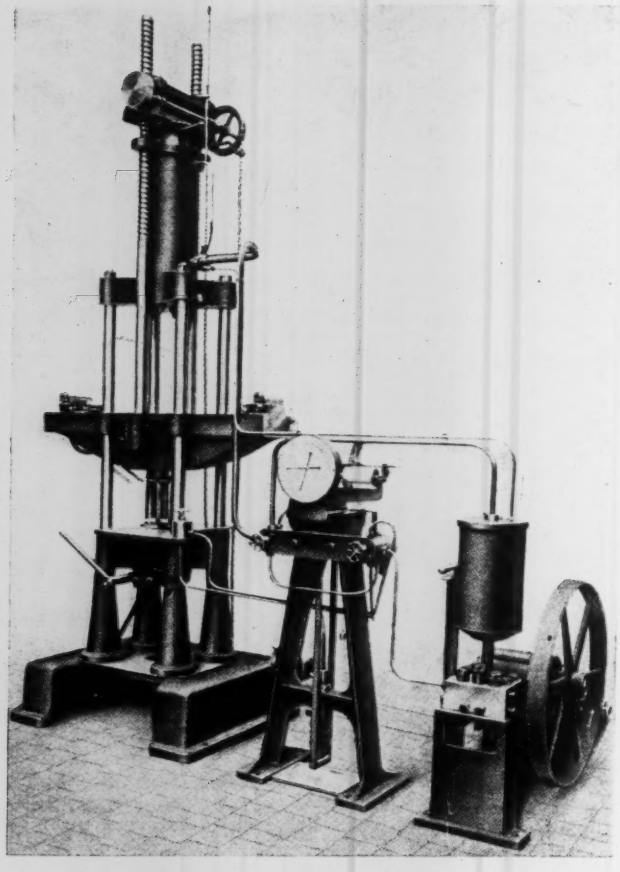

FIG. 5 AMSLER HYDRAULIC-TYPE TESTING MACHINE

such as bismuth and aluminum. Such a study is valuable in providing information on the behavior of polycrystalline material.

London University possesses the laboratory in which the original photoelastic investigations were developed by Prof. E. G. Coker, who is still in charge. This apparatus provides an ingenious method of studying stresses in machine parts and has proved very useful to designers and users of machinery.

Professor Coker's most recent published experiments treat of the stress conditions in notched beams.[13] This study applies to the hulls of ships which are provided with expansion joints. The stress distribution in a notched beam subjected to bending is shown in Fig. 6. A comparison may easily be made between the experimentally determined and calculated stresses. The stresses at the base of the notches are seen to be of considerable magnitude.

Professor Coker has developed a sensitive extensometer which is used in connection with photoelastic experiments for measuring the varying thicknesses of the specimen resulting from different degrees of stressing. The mirror principle is employed, and a record of the results of the measurements is traced on a drum by a spot of light.

The Metropolitan-Vickers Electrical Company's research department at Manchester, England, possesses a most interesting laboratory, under the supervision of R. W. Bailey. High-temperature "creep" tests in tension are being conducted there, and several experiments were recently made on tubular specimens of steel in tension and in torsion at high temperatures which indicate important possibilities.

The need for knowledge on the behavior of metal under the simultaneous action of continued high temperature and stress has only recently been severely felt due to the desire to increase economies in steam-power-plant operation and in the chemical industries. Many investigations are under way both in the United States and in Europe to determine data on which design of apparatus for such service may be based.

Lead has been used in tests to study creep characteristics. It is believed that an analogy exists between its behavior at room conditions and steel at higher temperatures. Lead pipe has also been submitted to internal pressure and simultaneous axial

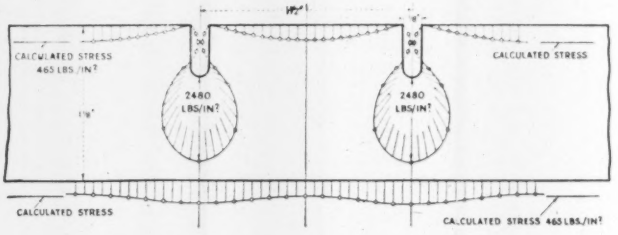

FIG. 6 STRESS DISTRIBUTION IN A NOTCHED BEAM SUBJECTED TO BENDING

loads, and some very interesting results of the effect of combined stresses have been obtained.

The new materials-testing laboratory of the Swedish Bureau of Standards is located in Stockholm. Several tension creep tests are now being made. The laboratory, which is a relatively small one, is equipped to do work in investigating the fatigue of metals, and the investigations are being conducted in a manner which indicates fine research technique.

ACKNOWLEDGMENT

The arrangements for visiting these laboratories and industries were effected by Prof. S. Timoshenko, and the author wishes to express to him his profound appreciation for thus making the trip possible.

[13] E. G. Coker and G. P. Coleman, "Stress Distributions in Notched Beams and Their Applications." Paper read before the Institution of Naval Architects, April 10, 1930. Abridged in *Engineering*, vol. 29 (1930), p. 576. See also "Lateral Extensometers," p. 465.

The Factor of Safety in Design

Two Definitions of the Term—Principal Objects of a Factor of Safety—Checking Failure Loads

By FRANK A. MICKLE,[1] ANN ARBOR, MICH.

A VERY interesting article was published in the November, 1930, issue of MECHANICAL ENGINEERING entitled, "How Safe Is a Factor of Safety?" This subject receives too little attention and consideration in design, and it will be well for us to look into it in more detail.

Two Definitions of Factor of Safety

There are two definitions of factor of safety found in different publications dealing with the design of machinery and allied products. One of these definitions states that the factor of safety is the ratio of the ultimate strength of the material in question to the allowable working stress of that material; the more recent one states that the factor of safety is the ratio of the elastic-limit strength of the material in question to the allowable working stress of that material. The first definition dates back to a time when considerably less was known about the strength and resistance of materials than we know now. The other is of rather recent date, and its value and importance are now realized by a good many engineers. The first definition, being much the older, is the one that we find used in many of our safety codes such as those for buildings, bridges, and boilers, where public safety is involved. This discussion is not intended to be a recommendation to change those codes. The fact that they and the factors of safety contained therein have stood the test of time speaks very well for the judgment of those who originally established the values to be used.

When we base a factor of safety on the ultimate strength of a material we must always keep in mind that the first thing to be accomplished is to have this factor large enough to bring the working stress below the elastic limit of the material. This consideration disappears when we use the second definition, as the elastic limit is the basis of reference.

It can be shown that the second definition is the more logical by a simple example. Let us suppose that a certain part of an existing machine was made from steel having an ultimate strength of 60,000 lb. per sq. in. and an elastic-limit strength of 35,000 lb. per sq. in., and that the designer, after careful consideration, decided that a factor of safety of four was the proper one to use. Now let us assume that the load on this machine member is to be doubled but the size is not to be changed. By selecting a different material with an ultimate strength of 120,000 lb. per sq. in., we should apparently have the same safety factor as in our original design. This conclusion is questionable. In the first case we should have an allowable working stress of 15,000 lb. per sq. in., and the machine part could carry an overload of 133 per cent before reaching the elastic limit. In the second case the allowable working stress would be 30,000 lb. per sq. in. This being a heat-treated material, in all probability its elastic limit would be in the neighborhood of 85,000 lb. per sq. in. In this case the same machine part made of a different material could carry an overload of 183 per cent. Assuming, then, that we based our factor of safety on the elastic-limit strength, we should find that we should need material that had an elastic limit of only 70,000 lb. per sq. in. instead of one with an ultimate strength of 120,000 lb. per sq. in., and an elastic limit of 85,000 lb. per sq. in. This change in requirements would materially change the heat-treatment specifications. In addition to the above illustration, we know that in general the ratio of the ultimate strength of heat-treated steel to the elastic-limit strength of that material is less than the similar ratio for non-heat-treated steels. From this also, then, it is apparent that the elastic-limit strength is the more logical basis for a factor of safety.

Principal Objects of a Factor of Safety

There are three principal objects of a factor of safety: first, to make sure that the working stress will be below the elastic limit of the material used; second, to take care of any lack of homogeneity of the material; and third, to take care of any indeterminate loads or stresses.

The proper determination of the factor of safety cannot be separated from the correct procedure in the design of any machine or machine element. The designer's first duty is to carefully analyze all loads acting on the machine part and to compute all determinable loads. In doing this he cannot help forming a very clear idea as to the probable magnitude of the indeterminate forces. He then probably fixes the forces that he knows exist but are not capable of being computed, as a percentage of his known forces. He next considers the material that he would like to use. Knowing the material, he is in a position to say what the liability of lack

[1] Assistant Professor of Mechanical Engineering, University of Michigan. Mem. A.S.M.E. Professor Mickle received the degree of M.E. at Ohio State University in 1912. He then entered the employ of the Buckeye Steel Castings Company, of Columbus, Ohio, as a designer. In the fall of 1914 he joined the teaching staff of the University of Michigan. Since then the majority of his time on the staff has been spent in teaching machine design. For the past seven years he has carried on commercial work in design and development for the Economy Baler Company, of Ann Arbor, Mich., designing and developing an electrically driven cotton compress. He is also active on the Sectional Committee for the Standardization of Herringbone Gears—sponsored by the A.S.M.E. and the A.G.M.A.

of homogeneity is. He also knows whether the value he is using is the true elastic limit or the yield point, and whether temperature conditions have been considered, and can readily make allowances to put his working stress below the true elastic limit. The designer, with this information at hand, will not think in terms of the factor of safety but in terms of the maximum probable working stress in the member. He will make an allowance for lack of homogeneity and for the purpose of having this maximum probable working stress below the true elastic limit. Then if he cares to know the factor of safety he can find the ratio of the elastic-limit strength to the computed existing stresses.

The practice of publishing factors of safety for general use is not to be commended. Almost every type of machine presents an entirely different problem. For example, a very heavily loaded machine is much less liable to be overloaded 100 per cent than a lightly loaded machine. A piece of high-grade heat-treated alloy steel is much more reliable than a piece of ordinary mill stock, and to allow the same percentage for lack of homogeneity would be unjust. It would not be out of the way to fix minimum values of factors of safety for cases where the maximum possible loads are known, and for definite classes of material, but even these are apt to be misused. If, however, any particular manufacturing organization is designing and manufacturing a line of machines that it knows will be subjected to abuse in direct proportion to their size, and if the same materials are used in like places in all of these machines, that manufacturing organization could readily establish a set of factors of safety for its own use and save considerable time and trouble.

CHECKING FAILURE LOADS

Many times when a piece of machinery fails in service the ultimate-failure load is computed and the manufacturer will claim—and prove his claim by use of these figures—that the machine had an excessively large overload on it. In other cases the manufacturer will test his machine to destruction and find that the failure load is below the computed failure load, and he will immediately claim that the designer did not use a large enough factor of safety or did not consider all loads acting. Both of these men are wrong in their assumptions. We must always bear in mind that all of our computations in strength and resistance of materials are based on Hooke's law, and that Hooke's law does not apply above the true elastic limit. In cases where any machine member is subjected to loads and stresses identical with those used in determining the physical properties of the material, one might check the failure load fairly closely, but these cases are very exceptional. Consequently, when a stress is found to be above the elastic-limit strength of the material we dare not say that if we load the member so as to apparently produce that stress, we shall have that stress existing. All we can say is that the member was loaded so as to produce a stress above the elastic limit.

In the article published in the November issue of MECHANICAL ENGINEERING, the author, Mr. J. Dilot, points out that pressure vessels can be built so that every part will be just as strong as every other part. This statement is without doubt true if great care is exercised in their manufacture. This care must involve truly cylindrical vessels, with no joints tending to produce bending in the plate either in a girth section or in a longitudinal section. It must involve perfectly homogeneous material with an absolutely uniform thickness and with no appurtenances attached thereto to cause localized stresses. However, if such a vessel were to be built and the bursting pressure computed, it is very doubtful if it would burst at this pressure. As Mr. Dilot points out, the physical properties should be determined under the same conditions under which the material is to be used. By this and from the remainder of the article he implies that he means under the same conditions of temperature. This is not the only thing that influences the ultimate strength of a material. We must bear in mind that when the physical properties of a material are determined they are usually determined by use of a standard test specimen of a given cross-section and length. To change either the cross-section or length would materially affect the ultimate strength of the material, because it would change the conditions of elongation and contraction of area. In a pressure vessel there is practically no chance for a contraction of area except in one direction, and the elongation will take place over a very long length. Under these conditions the ultimate strength of the material might be very different from that obtained under testing conditions. However, if strain gages were attached to the shell at various points of probable maximum stress and if the principal stresses were determined, it would probably be found that the elastic strength of the vessel would check very closely with the computed elastic strength.

In any machine or object subjected to stresses, if any one part or portion passes the elastic limit and is accompanied by the natural sudden increase in length, this deformation will in all probability throw unduly large stresses on other parts or portions and may cause localized failure even before the fact that some other part has passed the elastic limit is known.

If all designs were based on the strength at the elastic limit, if sincere attempts were made to compute all the determinate loads, and if a factor of safety were determined by logical reasoning, we should find our designs checking very closely with our predicted elastic-limit strength, and our factor of safety everything its name implies.

GALLIUM is a tough, grayish white metal, but soft enough to be cut with a knife. Its most interesting property is the wide range of temperature through which it remains liquid. The melting point is about 30 deg. cent., and its boiling point is in the neighborhood of 1700 deg. cent. The specific gravity varies from 5.9 in the solid state to 6.095 when molten.—*The Engineer*, Dec. 26, 1930, p. 707.

Stress Cycles in Gear Teeth

Computation of the Actual Maximum Stress at the Fillet of a Pinion Tooth for Various Positions of the Load, Assuming But One Tooth in Contact at Any Time

By R. V. BAUD,[1] EAST PITTSBURGH, PA., AND E. HALL,[2] LUBBOCK, TEX.

IN A PREVIOUS paper in MECHANICAL ENGINEERING[3] certain analytical and photoelastic results on the load and stress cycles of gear teeth were published. In Figs. 14 and 16 of this earlier paper so-called single-tooth stress curves were given, which are also shown in Fig. 1 in the present paper. The following statement concerning these curves was made:

R. V. BAUD

ELMER HALL

> The single-tooth curve for the tension side gives a fairly constant stress which for the whole cycle is smaller than the one on the compression side. This confirms a previous photoelastic test made on gears,[4] from which it was also concluded that the maximum fillet stress on the compression side is larger than the one on the tension side. However, the shape of the single-tooth stress curves cannot be readily explained, and since these curves are of considerable importance, it is contemplated to repeat this experiment with improved test conditions, in which we shall have larger teeth without initial stresses and in which we contemplate using the compensation method and applying only torque of such magnitude that the stresses will be within the proportional limit of the material.

These tests have been completed, and it is the object of this paper to discuss the results obtained and to give simple rules by which it will be possible to approximate the stress cycles for similar teeth.

LOADING ARRANGEMENT

Before discussing the arrangement used, it may be well to review briefly the authors' photoelastic tests on gears.

The first tests were made with models having one large tooth only.[5] Forces were applied as shown in Fig. 2, (*b*)[6] and (*c*), and it was thought that by combining the results the true stress condition from a force such as shown in Fig. 2 (*a*) could be obtained in this manner.

Later on it was realized[7] that the stress at the fillet should be known for different positions of the bending force, and tests were made on a model having semicircular notches as shown in Fig. 3, in which the load was applied at the different notches by means of a pin.

The next step in the development was to make small gears and to apply a load to the driven gear by the driver as in actual operation. In obtaining the single-tooth stress curves in this particular test the teeth adjacent to the one being tested were removed, so that only one tooth was in contact at all times (see Fig. 4). It is the results from this test to which the statement in the introduction refers.

In the test which is to be described here, the models were made of $^1/_4$-in.-thick celluloid in the form of gear segments and loaded by the arrangement shown in Fig. 5. By means of the adjustments on this arrangement it was possible to place the models in the positions that would be passed through by gears in actual operation. Eleven different angular positions were used in taking the photoelastic stress readings in the fillets of the pinion. Before taking these readings, however, excess material was removed from the faces of the gear teeth adjacent to the one used for loading so that only one tooth would be in contact for all positions. In order to eliminate frictional forces at the point of contact, the models were placed in the desired position and then loaded, instead of letting them come into position with the load applied. By this means the condition of static loading was obtained, which is desirable, because no lubricant was used in the test.

GEAR DATA

The following data, together with the information given in Fig. 6, describe the pinion tested. The teeth in the model were machined by employing the same form cutters as were used to cut the actual pinion.

Tooth Form: Long addendum with an unmodified involute-curve tooth outline without tip relief.

Pressure Angle: 20 deg.

Diametral Pitch: $1^3/_4$.

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[1] In charge of photoelastic stress analysis in the Mechanics Division of the Research Laboratories of the Westinghouse Electric & Manufacturing Co. Mr. Baud was graduated in 1920 from the Technical University of Zurich, having been a pupil of Professor Stodola. After one year of post-graduate work at the Technical University of Charlottenburg, he was employed by the German General Electric Co. in their offices at Berlin and Sao Paulo, Brazil, on power-plant work. Prior to taking up his present work in 1925, he had charge of the layout of heating systems in New York.

[2] Instructor, Texas College of Technology. Jun. A.S.M.E. Mr. Hall was graduated from the State College of Washington in 1928, and entered the employ of the Westinghouse Electric & Manufacturing Co. the same year. He obtained his M.S. degree from the University of Pittsburgh. He assumed his present duties in the fall of 1930.

[3] "Load and Stress Cycles in Gear Teeth," Baud and Peterson, MECHANICAL ENGINEERING, vol. 51, no. 9, pp. 653–662.

[4] "Study of Stresses by Means of Polarized Light and Transparencies," Baud, Proc. Eng. Soc. W. Pa., vol. 44, no. 6, July, 1928.

[5] "Strength of Gear Teeth," Timoshenko and Baud, MECHANICAL ENGINEERING, vol. 48, no. 11, pp. 1105–1109.

[6] The tests were made with a tensile force. It was assumed that the stresses due to a compressive force are equal in magnitude and opposite in sign to those produced by a tensile force.

[7] "Study of Stresses by Means of Polarized Light and Transparencies," loc. cit., p. 215.

The fillet at the root of the tooth tested was designed with an arc of a circle having a radius of 0.225 in. This design of the tooth root was suggested by one of the authors as early as 1926 on the basis of the first series of photoelastic tests on gears, and has been recommended by him consistently ever since.[8]

RESULTS

The maximum stresses obtained for the fillets of the pinion were plotted against the position along the line of action, giving curves I and II in Fig. 7. In this figure, B is the point of engagement, P the pitch point, and A the point of disengagement.

The location of maximum stress is shown in Fig. 6.

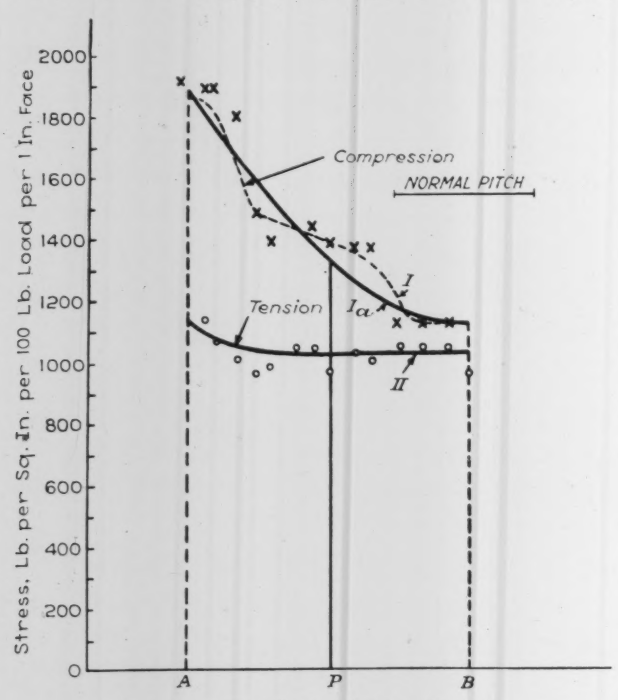

FIG. 1 SINGLE-TOOTH STRESS CURVES

For engagement the maximum stress occurs at point B. This position does not remain the same for different points of load applications but shifts along the flank in the same direction as the point of contact, until it reaches the point A, which is the point of maximum fillet stress for disengagement.

In order to compare these results with the theoretical bending stress, the beam equation

$$S_A = \frac{6Pl}{c^2} \quad \text{.....[1]}$$

was used, and curve III, Fig. 7, was obtained. In this equation

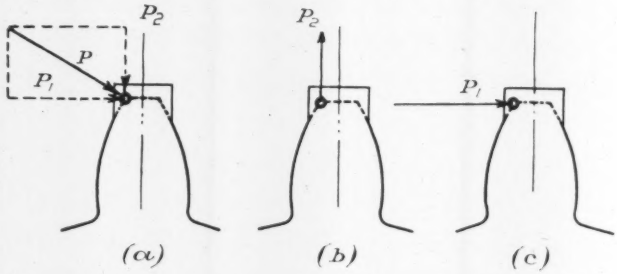

FIG. 2 METHODS BY WHICH FORCES WERE APPLIED TO TOOTH TESTED

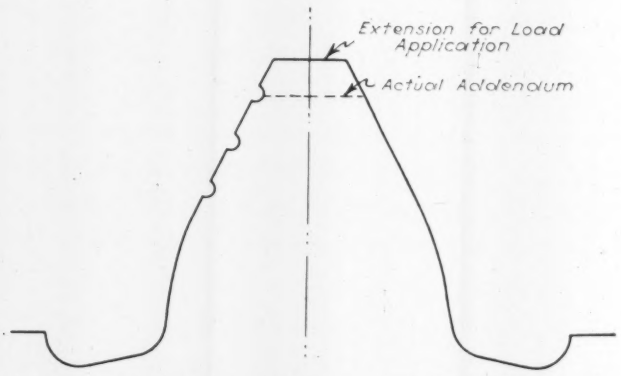

FIG. 3 TOOTH NOTCHED FOR APPLICATION OF FORCE THROUGH PIN

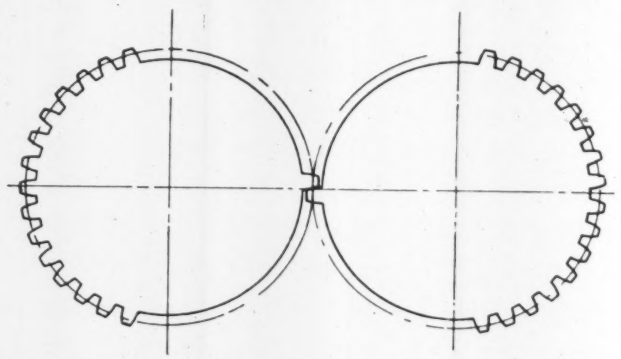

FIG. 4 GEARS FROM WHICH THE SINGLE-TOOTH STRESS CURVES SHOWN IN FIG. 1 WERE OBTAINED

P = 100 lb. per inch of face width acting along the line of action

l = variable perpendicular distance from the line of action to the intersection I, Fig. 6, of the working depth circle[9] and the tooth center line

c = tooth thickness at a line tangent to the working depth circle; see cross-sectional dimension N-N in Fig. 6.

It should be noted that in computing the bending stress as outlined above, the same result is obtained as if the bending were computed in two separate steps

[8] A remarkable confirmation of the fact that increased fatigue strength is secured with a semicircular fillet was obtained from experiments that were made by the National Physical Laboratory. To quote from its report for the year 1929 (p. 196):

"In the course of the work some special tests have been made which possess interest. For example, a set of gears ground with a smooth semicircular curve at the root have been found to have remarkable endurance as compared with the common form of root fillet. Although the modified tooth, owing to its greater length, was found to have a considerably smaller statical breaking strength, it was still unbroken after 47½ million revolutions at 1500 r.p.m. with a tooth load of 1500 lb. per inch of tooth width. Under the same conditions the standard tooth was found to have an average life of about 8 million revolutions."

[9] "Marks' Handbook," Third Edition, p. 920.

as shown in Fig. 2, (*b*) and (*c*), neglecting the compression stress P_2/c. This computed compression stress is very small compared with the bending stress, and is always neglected in computing fillet stresses. This is not a legitimate procedure in computing fillet stresses, however, as will now be seen from the following discussion.

DISCUSSION

(*a*) *Concerning the Statement Mentioned in the Introduction.* By comparing Figs. 1 and 7 it will be seen that the character of the corresponding curves is very much the same, especially if we replace in Fig. 1 the curve I by I_a, which we believe is the correct curve. Some difference in the shape of the curves and especially in the numerical values is to be expected owing to the different shape of the tooth tested. As a whole, however, it is thought that the statement, "The compression stresses are larger than the tensile stresses for the major part of the stress cycle in a gear," is now proved beyond doubt.

(*b*) *Concerning the Comparison of True and Computed Fillet Stresses.* If the computation of fillet stress as produced by the forces P_1 and P_2 shown in Fig. 2, (*b*) and (*c*), were correct, then curve I would differ from curve II only very slightly due to the additional computed compression stress P_2/c, and furthermore the two would very nearly coincide with curve III. Instead of this we not only find a large difference between curves I and II, but also between curves I and III, and curves II and III. From this it is concluded that the standard method of computing gear stresses is very much in error.

RECOMMENDATIONS

When using Equation [1] to compute the fillet stress for a load applied at the tip, the error consists chiefly in that the concentration of stress is neglected A factor k has to be included in Equation [1],

$$S_{\max} = k \frac{6Pl}{c^2} \quad \ldots\ldots\ldots\ldots\ldots [2]$$

in order to account for this concentration. From previous tests it was found that this factor can be computed from the equation[10]

$$k = 1 + \frac{0.15c}{R} \quad \ldots\ldots\ldots\ldots\ldots [3]$$

where R is the fillet radius and c the width of the section as in Equation [1]. The tests from which this empirical equation was derived were made on somewhat slenderer teeth, having extensions and bushings at the top of the tooth, the load being applied by means of a pin.[10] It is to be expected that for a different type of loading mechanism, such as was used in this test, the factor k would have to be modified somewhat, namely, as indicated by Equations [4] and [5].

$$k_T = 0.8\,k \quad \ldots\ldots\ldots\ldots\ldots [4]$$

$$k_C = 1.1\,k \quad \ldots\ldots\ldots\ldots\ldots [5]$$

the subscripts T and C denoting tension and compression, respectively.

If it is desired, therefore, to compute the maximum stresses S_T and S_C (see Fig. 7), Equations [6] and [7],

$$S_T = k_T \frac{6Pl}{c^2} \quad \ldots\ldots\ldots\ldots\ldots [6]$$

$$S_C = k_C \frac{6Pl}{c^2} \quad \ldots\ldots\ldots\ldots\ldots [7]$$

should be used.

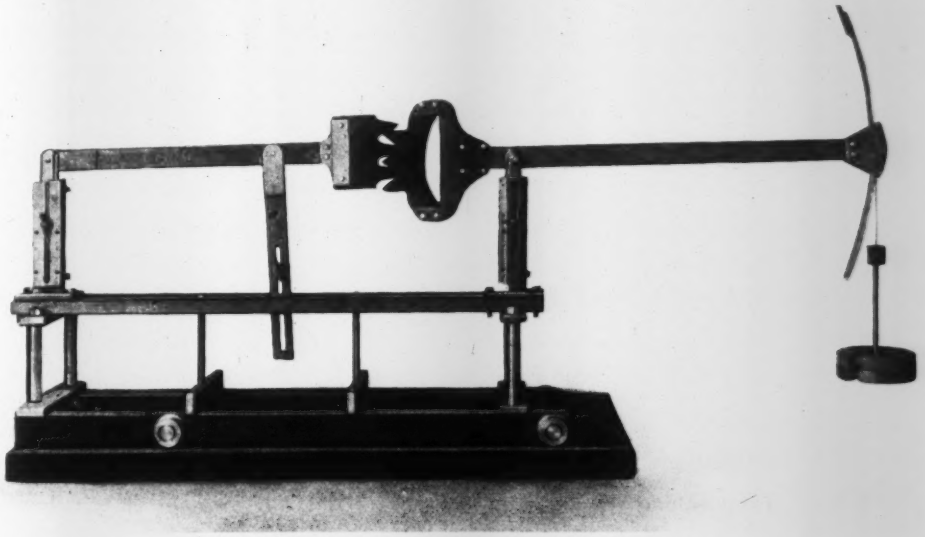

FIG. 5 APPARATUS USED IN TESTING CELLULOID GEAR SEGMENT

With improvements in the art of gear cutting the load division between different pairs of teeth in mesh may be taken into consideration.[11] For this purpose it is necessary to compute not only the stresses S_C and S_T, but the whole stress cycle as well. To do this the designer may proceed as follows:

Referring to Fig. 8, on the line of action plot the points S_A and S'_A, where S_A is the stress computed from Equation [1] and $S'_A = 0.8\,S_A$. Also plot the points S_T and S_C as obtained from Equations [6] and [7]. Then construct the lines $S_AS'_A$, S_CB, and S_TB, and draw the stress-cycle curves in such a way that these lines are tangent to them as shown. The

[10] Loc. cit., "Strength of Gear Teeth," p. 1107.

[11] Loc. cit., "Load and Stress Cycles in Gear Teeth."

experimental curves are shown by broken lines in Fig. 8.

The stress-cycle curve for the case where the load is carried by more than one tooth is then obtained by multiplying the single-tooth stress-cycle curve by the "per cent total load" figures, which may be computed in the manner as suggested in a previous paper.[3]

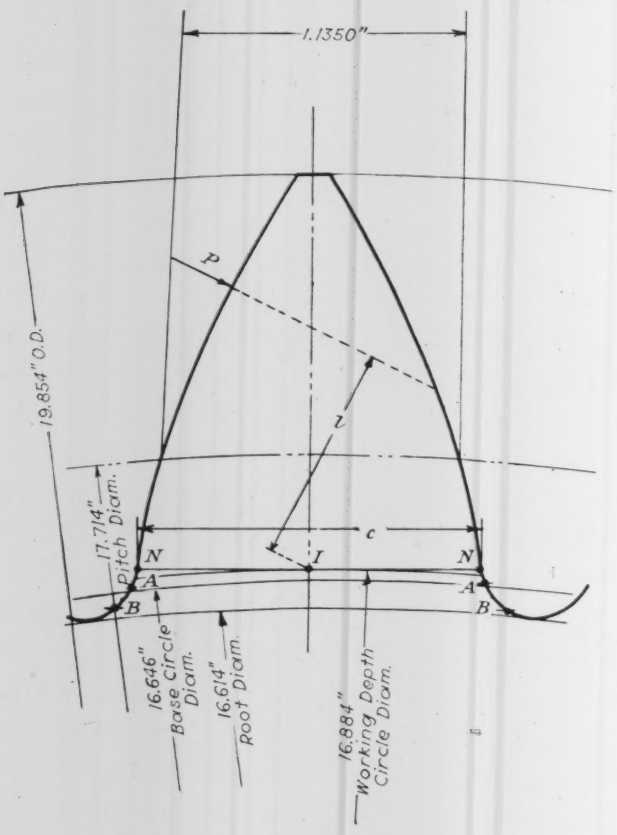

FIG. 6 DIMENSIONS OF TOOTH TESTED

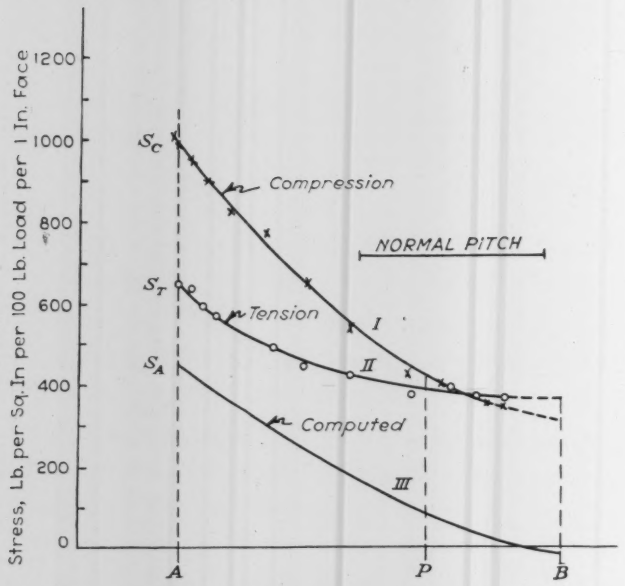

FIG. 7 COMPARISON OF MEASURED AND COMPUTED STRESSES

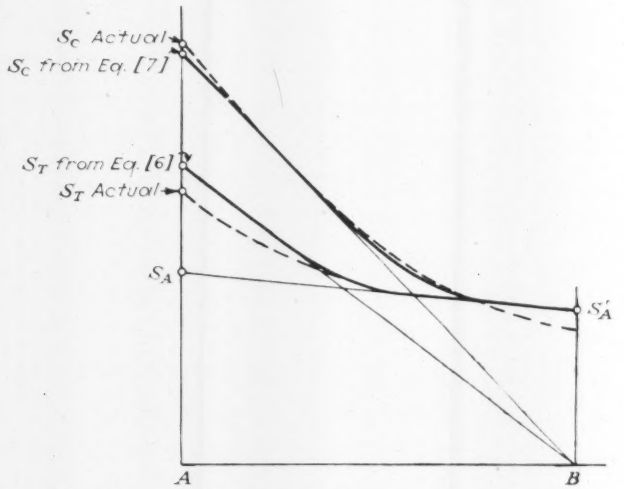

FIG. 8 METHOD OF LAYING OUT SINGLE-TOOTH STRESS-CYCLE CURVES ON BASIS OF RULES GIVEN IN TEXT

Depreciation a Direct Cost

ALL costs must be recovered with a profit if a business is to prosper and continue. Depreciation or the gradual decline in value and wearing out of property is a cost that must be recouped. Without such a cost included as a part of total cost, how can assurance be had that a sufficient sum is being recovered through selling prices to protect the business? If this is not done eventual failure will result. The charging of a sufficient amount for depreciation into costs, and based on present-day values of the properties, provides a reserve sufficient to meet actual replacement requirements, as the reserve will fluctuate in accordance with market prices of the facilities being used. It is a serious matter for the manager to find that at the end of the useful life of a machine his reserve is inadequate to purchase another like machine.

Today there is a more rapid turnover of plant equipment, the adoption of newer processes, and other changes of a radical nature. This development must be reflected in depreciation charges to cost, for, if they are not, costs cannot be correct. Present-day conditions demand that proper rates for depreciation be used. In former years a flat 10 per cent rate applied to an entire plant was deemed to be adequate. Recently it has been found practicable to determine separate rates for each class of property. For example, 15 years ago 5 per cent was considered sufficient for machine tools. Today the average machine tool becomes obsolete in even less than 10 years, to say nothing of the actual wear and tear. A 10 per cent rate is hardly adequate for that class of equipment. Each industry has its own problems and the managers and their accountants must study conditions that affect their particular industry very carefully when setting their rates.—Thos. B. Frank, in *The Iron Age*, Jan. 29, 1931, p. 374.

Fatigue Tests of Model Turbo-Generator Rotors

Results of Tests of Rotor End Forgings to Obtain Data as to Safety During Operation—Tests With Fatigue Loading Only, and With Superimposed Centrifugal Stressing

By R. E. PETERSON,[1] EAST PITTSBURGH, PA.

THE tendency to increase the size of generating equipment[2] has made it necessary to obtain data concerning the strength of rotors. Since the kinetic energy of a rotor of large size, such as shown in Fig. 1, operating at 1800 r.p.m. is tremendous, it is important to have definite information as to the factor of safety.

One of the critical sections of a rotor of the plate type[3] is at the fillet of the end forging (*A*, Fig. 1). This section is subjected during rotation to combined steady centrifugal stresses and alternating bending stresses, the latter being due to the weight of the rotor. Because of the presence of ventilation holes at the fillet section and the combined stress condition stated above, a strength problem arises which cannot be solved by making use of the ordinary test properties of the material. Along with the development of large fatigue-testing equipment[4] it was decided to make a series of fatigue tests of rotor models to determine the effect of alternating fatigue stresses alone, and after this to make tests in a pit with the effect of centrifugal stresses added.

Tests With Fatigue Loading Only

The fatigue tests were made in a rotating cantilever-beam-type machine of large capacity.[4] The models were made approximately $^1/_{12}$ size as shown in Fig. 1, with all the details in the region of failure (fillet, vent holes, bolts, etc.) made to scale.[5] The only part not to scale in the model was the long shaft portion which makes it possible to apply large bending moments to the specimen without excessive loads. This deviation from geometrical similarity caused no appreciable error since the question of direct shear can be shown to be unimportant. A photograph of a finished specimen is shown in Fig. 2. The ventilation holes, which can be seen clearly in Figs. 2 and 3, were drilled with a jig and reamed to $^5/_{32}$ in. diameter, corresponding to 2 in. diameter in the actual rotor. The holes were drilled staggered with respect to the angle made with the rotor axis, as is apparent from Figs. 2 and 3. The purpose of the staggered arrangement in the large rotors is to prevent the holes from running together at the inside.

The models were made from small upset forgings ordered to be representative of the material in large forgings. Detailed information concerning this material[6] is given in Table 1. Metallographic examination showed the material of the models to be essentially the same as that of the large rotor forgings.

TABLE 1 MATERIAL FOR ROTOR FORGINGS

Chemical composition:	
0.57 C, 0.60 Mn, 0.037 P, 0.039 S, 0.26 Si	
Heat treatment as per footnote 5.	
Physical properties:	
Yield point	67,000 lb. per sq. in.
Ultimate strength	102,000 lb. per sq. in.
Endurance limit	49,000 lb. per sq. in.
Elongation	20 per cent
Reduction of area	41 per cent

In making model tests a question arises as to a possible variation of physical properties with size alone. Tensile properties of ordinary steels are known to be independent of size for geometrically similar test pieces. This is to be expected if static tensile strength is thought of as a statistical average effect, involving even in small specimens thousands of grains. It should perhaps be pointed out here that the high tensile strength of wires is due to cold working and not to small size. Recent fatigue tests[7] on specimens varying in diameter from 0.050 in. to 2.000 in., a ratio

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[2] Henderson and Soderberg, "Recent Improvements in Turbine Generators." Jl. A.I.E.E., Feb., 1928.

[3] DenHartog, "The Mechanics of Plate Rotors for Turbo-Generators." Trans. A.S.M.E., vol. 51(1929), paper APM-51-1.

[4] Peterson, "Fatigue Tests of Large Specimens." Trans. A.S.T.M., vol. 29 (1929), part II, p. 371.

[5] For a general discussion of testing of models in various engineering fields, see Johansen, "Research in Engineering by Small-Scale Apparatus," *The Engineer*, vol. 147 (1929), p. 318.

[6] Merten, "High-Temperature Treatments of Castings and Forgings as Evidenced by Core-Drill Tests From Heavy Sections." Jl. A.S.S.T., Jan., 1928.

[7] Peterson, "Fatigue Tests of Small Specimens With Particular Reference to Size Effect." Paper before A.S.S.T., Sept., 1930.

of 1 to 40, indicate that at least for ordinary steels there is no important size effect in fatigue. One of the materials tested in the size-effect investigation was the rotor material used in these tests.

Three conditions were tested in the fatigue models: (1) no ventilation holes (fillet effect only); (2) six holes in shaft—twenty-four holes in fillet; (3) twenty-four holes in fillet—no holes in shaft. The test data are given in Table 2, and shown graphically in Fig. 4. A summary of significant values is given in Table 3. The endurance limits are given as nominal stresses based on use of the flexure formula $S = M/(I/c)$, where I/c is the section modulus of the shaft. Computing the nominal bending stress in an actual rotor in the same manner, a value of 2860 lb. per sq. in. was obtained. The factor of safety against alternating stresses alone is then obtained by dividing the values in the first column of Table 3 by 2860. It is seen that the factors of safety vary from 7.7 to 9.8, indicating a large margin of safety. A value of the factor of safety of 3 has been recommended[8] in machine-design practice for alternating stresses where no impact loading occurs. In some cases factors of safety are written into specifications,[9] but this is open to question since the factor of safety depends on the basic assumptions made in computation.

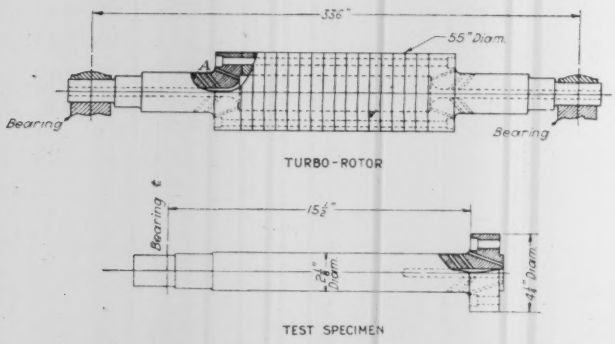

FIG. 1 ACTUAL TURBO-ROTOR AND TEST SPECIMEN

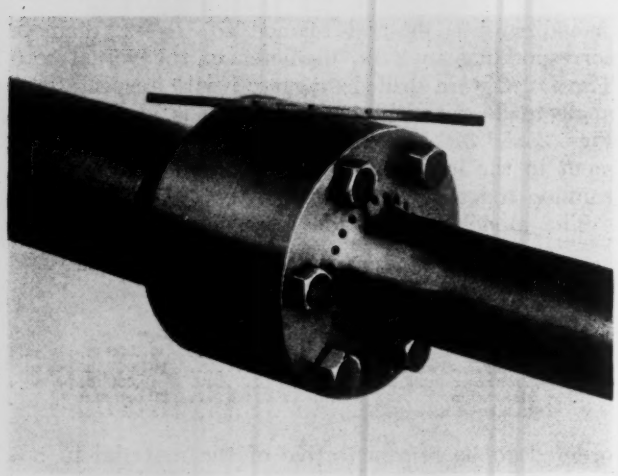

FIG. 2 ASSEMBLED MODEL ROTOR FATIGUE SPECIMEN

TABLE 2 FATIGUE-TEST DATA

No.	Nominal stress, lb. per sq. in.	Cycles	Notes
1	32,700	204,000	24 holes in fillet, 6 holes in shaft; fracture through 6 holes
2	36,500	92,000	Do.
3	28,500	442,000	Do.
4	23,700	2,179,000	Do.
5	21,200	10,000,000	Do. (No failure)
6	36,500	206,000	24 holes in fillet, no holes in shaft; fracture through 24 holes
7	26,900	2,945,000	Do.
8	24,800	9,928,000	Do.
9	28,500	1,117,000	Do.
10	34,400	196,800	No holes; failure in fillet
11	30,000	834,000	Do.
12	28,100	10,700,000	Do. No failure.

TABLE 3 SUMMARY OF DATA

	Endurance limit, lb. per sq. in.	Factor of safety
No holes (fillet effect only)	28,100	9.8
No holes in shaft, 24 holes in fillet	24,800	8.6
Six holes in shaft, 24 holes in fillet	22,000	7.7

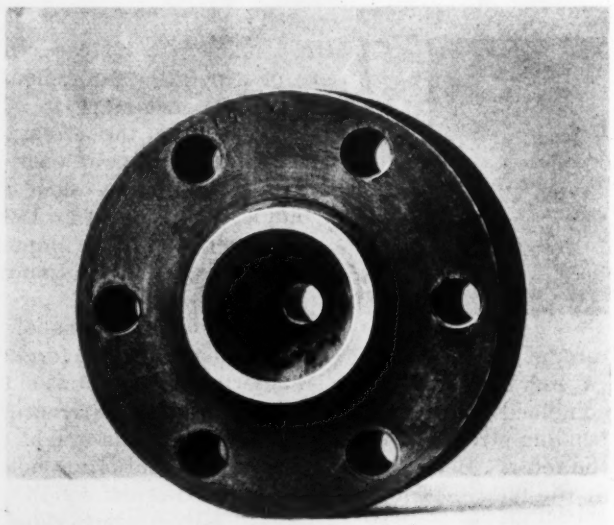

FIG. 3 REAR VIEW OF MODEL ROTOR FATIGUE SPECIMEN

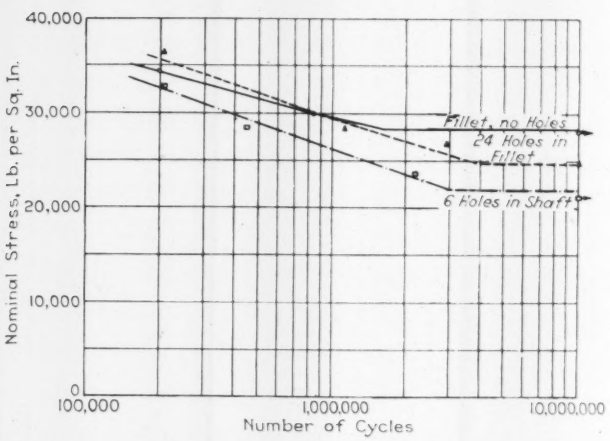

FIG. 4 MODEL ROTOR FATIGUE TEST

It is apparent from Table 3 that the holes do not

[8] Marks, "Mechanical Engineers' Handbook," 3rd ed., p. 428.

[9] Kuyser, "Recent Developments in Turbo-Generators." Jl. Inst. E.E., vol. 67, (1929), p. 1113.

greatly weaken the rotor in fatigue. This may at first seem surprising when it is generally known that the weakening effect of a hole in an ordinary fatigue specimen of steel is quite large.[10] The answer is that in the rotor tests a stress-concentration effect already exists due to the fillet (which cannot be avoided and is limited in maximum radius), and that a superimposed stress concentration due to the holes does not have the same effect as when acting alone. In other words, one cannot add or multiply fatigue-stress concentration factors.

Photographs of fractures are shown in Figs. 5 and 6. In Fig. 5 it is interesting to note that cracks started from both sides of each hole and progressed simultaneously in a helical manner until they joined midway between the holes. Final fracture is indicated by the region of crystalline appearance.

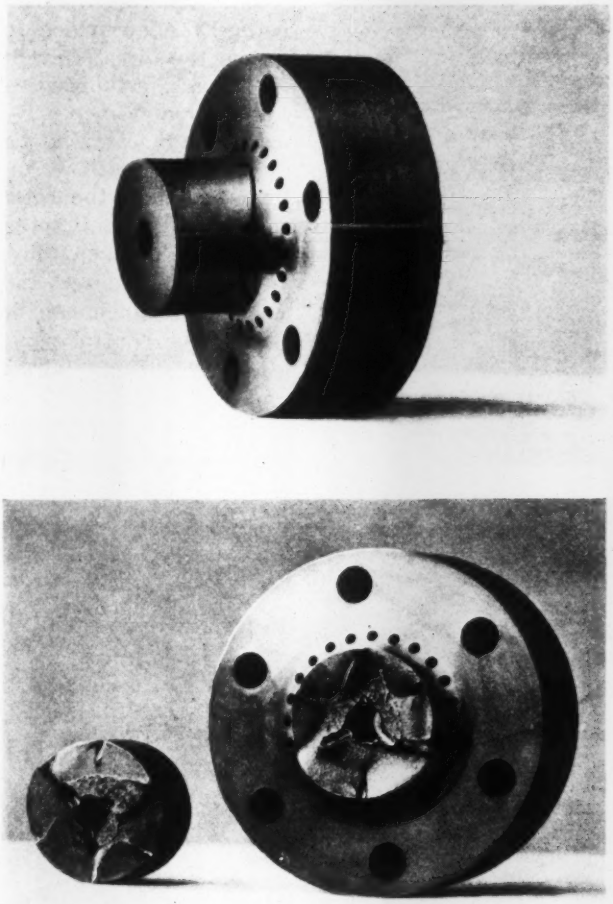

FIG. 5 FRACTURE OF SPECIMEN WITH HOLES IN SHAFT

SUPERIMPOSED CENTRIFUGAL STRESSING

At the fillet of an actual rotor there is in addition to the alternating stresses a constant stress effect due to centrifugal force in the rotor body. The problem of testing such a combination of stresses has necessitated the design and construction of a pit, which is shown in cross-sectional elevation in Fig. 7. The

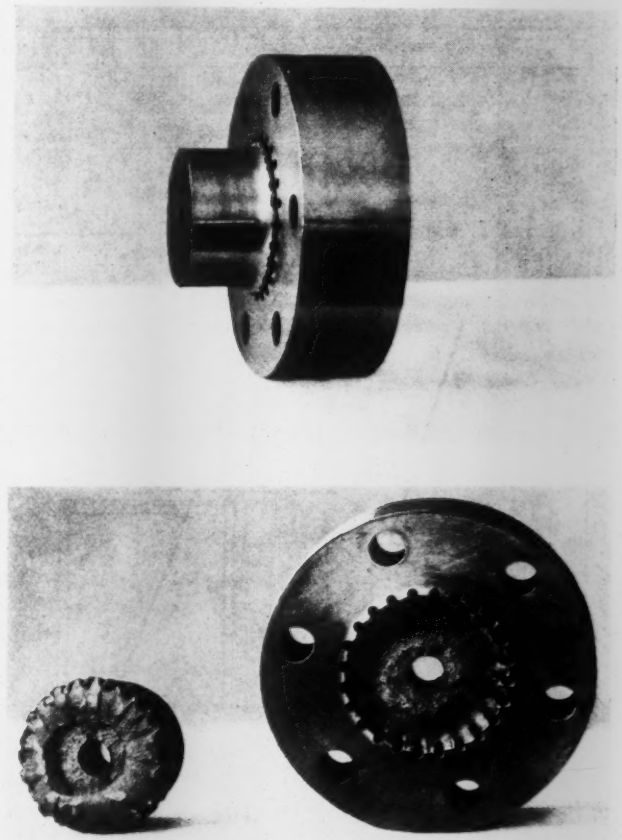

FIG. 6 FRACTURE OF SPECIMEN WITH HOLES IN FILLET

diameter of the pit is 10 ft. and the depth 8 ft. The walls and bottom floor are of concrete 8 in. thick. The working parts are supported by heavy 10-in. channels welded together and embedded in the concrete. A photograph taken during the construction of the pit is shown in Fig. 8. The completed pit is covered with a wooden floor (Fig. 7), so that the driving motor is the only part of the pit proper which projects above the floor. There is a trap door in the floor, and by means of ladders easy access is had to an intermediate floor and to the basement of the pit.

The testing arrangement can be seen in Fig. 7. The axis is chosen vertical so that any unsymmetrical part, such as a rotor tooth, failing at high speed will be thrown in a horizontal plane. In this manner provision can be made to absorb a tremendous amount of energy without great danger to the operator or to the equipment.[11] The vertical motor (ball-bearing type) is connected by a flexible coupling to a heavy

[10] Moore and Jasper, "An Investigation of the Fatigue of Metals." Univ. of Ill. Exp. Sta. Bulletin No. 152, p. 25. The following reference is also of interest in this connection: Timoshenko and Dietz, "Stress Concentration Produced by Fillets and Holes." Trans. A.S.M.E., vol. 48(1926), p. 199.

[11] In this connection the following reference is of interest: Lasche, "Materials and Design in Turbo-Generator Plants," pp. 21–23. Published by Oliver and Boyd, Edinburgh.

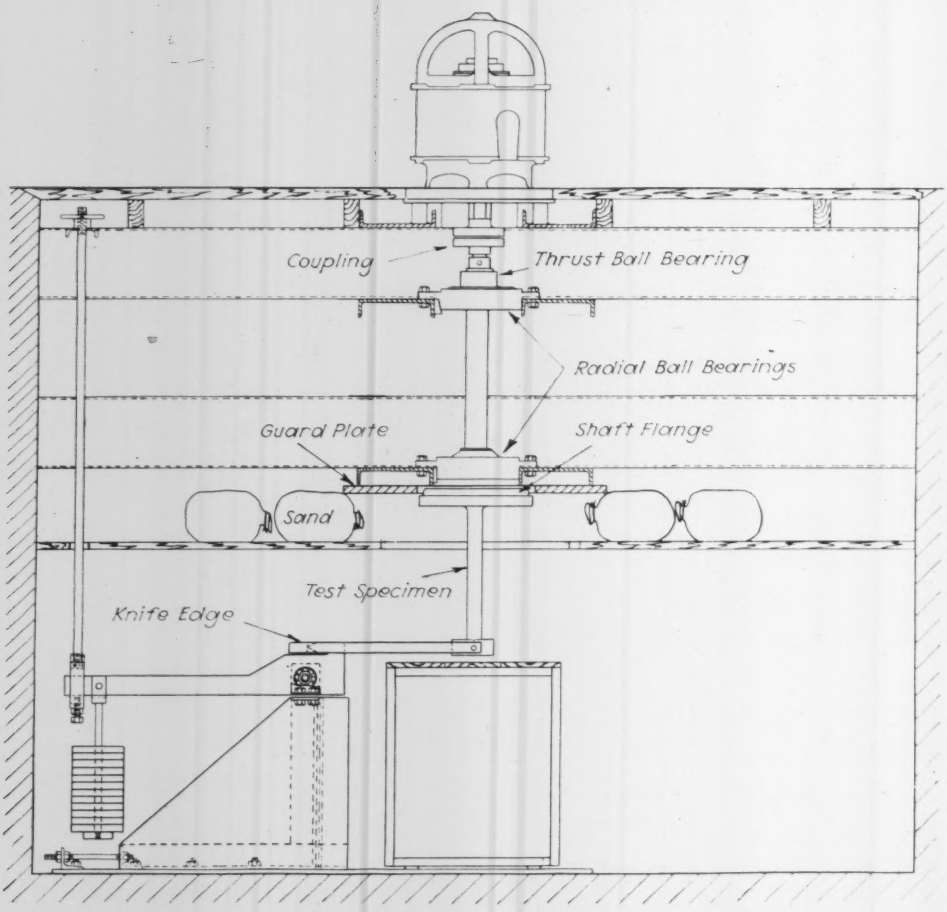

FIG. 7 APPARATUS FOR OVERSPEED PIT TEST OF MODEL ROTOR

shaft which is supported by two self-aligning ball bearings and a thrust bearing which supports the weight of the rotating parts. The bearing housings are fitted tightly against the channels by means of wedge blocks so that the radial impact occurring at failure will come directly against the channels and not against the bolts.

The test piece (Fig. 9) is fastened to the shaft by means of bolts which are made to scale with the essential model details. The test piece is the same as the test piece used for the fatigue tests (Fig. 2) except for the flanged portion, which is for the purpose of applying the centrifugal stress. In order to obtain a stress at the fillet corresponding to that due to centrifugal force in the large rotor, it was necessary in the model to make the teeth very long and heavy. The shaft is flanged where the test piece is attached to prevent any rotor teeth which might be thrown out from going in an upward direction. A heavy guard plate (Fig. 7) welded to the channels is also provided for the same purpose.

The alternating bending stress is obtained in a manner essentially the same as in an ordinary fatigue test. The shaft part of the test piece is a rotating cantilever beam subjected to a horizontal pull by means of the lever system shown in Fig. 7. By means of a vertical rod, the dead-weight load can be supported until the test piece has been brought up to speed, when the load can be put into effect without going down into the pit, by turning the handwheel shown in Fig. 7. The purpose of the intermediate platform is to support sand bags as shown.

The driving motor is a 20-hp. d.c. machine with a rated speed of 3450 r.p.m. A motor-generator set has been provided to furnish the direct current so that a constant speed can be maintained. By means of a rheostat having a motor drive with worm-gear reduction, the rotor can be brought up to speed very slowly and smoothly. An electric counter and tachometer which can be read at the control panel are also provided. Wiring is provided all about the specimen with a relay system, so that at failure the motor will be shut off.

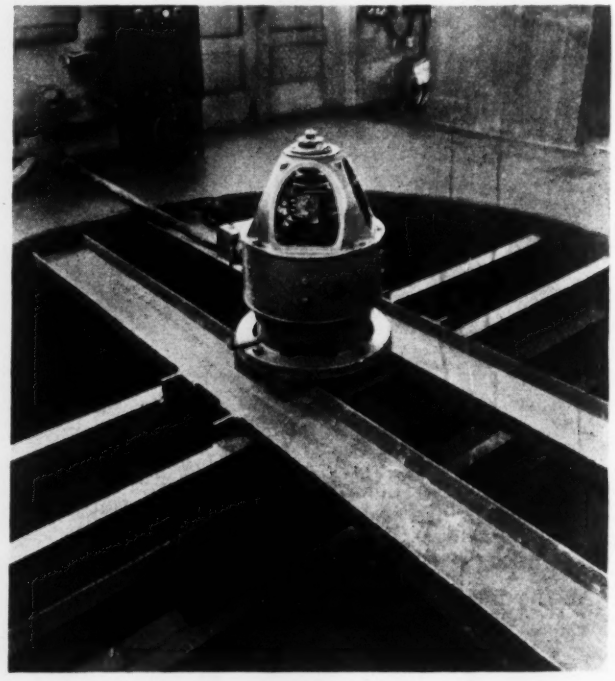

FIG. 8 TEST PIT DURING CONSTRUCTION

A photograph of a rotor tested in the pit is shown in Fig. 10. This rotor had twenty-four holes in the fillet and none in the shaft. It will be noticed that the fracture is of the same type as that shown in Fig. 6. A tensile stress was applied in the above-mentioned test by the centrifugal loading, corresponding to the centrifugal effect in the actual turbo-rotor at operating speed. Although there is an effect due to centrifugal loading, it is thought that this will not reduce the endurance limit previously found by more than 15 per cent. This still leaves a large margin of safety. A consideration of the action of a plate rotor as a whole due to centrifugal effect shows that the model test represents a stress condition somewhat more severe than that of the actual rotor.

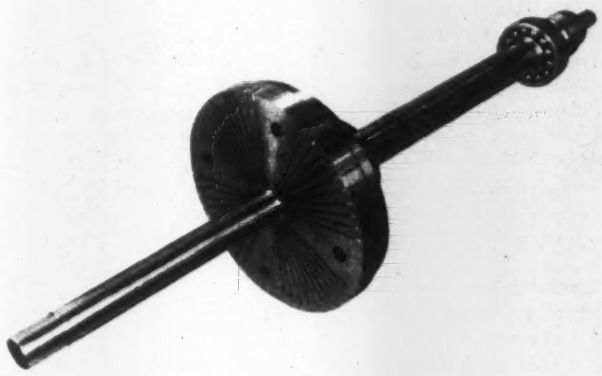

FIG. 9 TEST SPECIMEN FOR CENTRIFUGAL LOADING

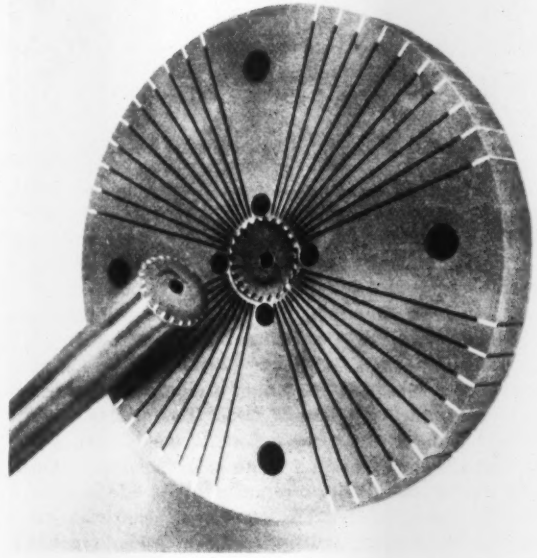

FIG. 10 FRACTURE OF SPECIMEN SHOWN IN FIG. 9

CONCLUSIONS

1 Tests of model rotors subjected to fatigue loading only show that the factor of safety varies from 7.7 to 9.8 for the designs tested.

2 The effect of a combination of hole and fillet does not seem to be as dangerous as might be expected. Stress-concentration factors apparently do not add in such a case.

3 The effect of superimposed tension at the rotor fillet due to centrifugal loading causes a reduction of fatigue strength of not more than 15 per cent, which still leaves a large margin of safety.

4 The equipment for testing model rotors makes it possible to study in a systematic manner the possibilities of various designs, to the end that the safety of large units be further insured and that information for guidance in the design of still larger rotors be obtained in a fundamental manner.

ACKNOWLEDGMENTS

The author has been assisted by Messrs. F. C. Cassel and C. H. Jennings in certain phases of the work. Information concerning large rotors has been supplied by Messrs. S. L. Henderson and B. A. Rose. Valuable suggestions have been made by Dr. S. Timoshenko and Messrs. C. R. Soderberg and J. M. Lessells.

Chemical Engineering

"CHEMICAL engineering," as its name implies, relates to the activities of one whose business lies with the design and construction and maintenance of chemical plant, using that term in its widest sense. We have repeatedly heard it said that the "chemical engineer" must combine the knowledge of the chemist with that of the engineer, but it is not so fully realized that to a very large extent the "chemical" knowledge which is required is in reality metallurgical knowledge.

The problems of chemical engineering are, in the majority of cases, particular aspects of the great general problem of corrosion, and it is the insight into the fundamental connection between resistance to chemical attack and the constitution and structure of alloys that can alone assist in arriving at better materials and at more scientifically correct applications of known materials and treatments. In this connection it is interesting to note that while, for the purpose of resisting ordinary atmospheric and other corrosion the metallurgist of today is largely occupying himself with the problem of finding good protective coatings, Dr. Seligman, president of the Institute of Metals, recently emphasized the point that for chemical plant any surface coating must be of the "self-healing" type, such as the ordinary oxide coating on aluminum or the surface skin of the iron-chromium alloy steels. It is by no means impossible that self-protecting alloys of this type may be found with a basis of copper, silver, or aluminum. As yet we know very little about this important subject, and it represents only one of many points where the problems of chemical engineering are intimately related to the problems of metallurgical research.—*The Metallurgist* (Supplement to *The Engineer*), December 26, 1930, p. 178.

Survey of Engineering Progress

A Review of Attainment in Mechanical Engineering and Related Fields

ENGINEERING MATERIALS (See also Special Processes: Pressure Die Castings of Aluminum Bronze)

Effects of Annealing on Chains

THIS is the final report of a committee of the National Safety Council. There has always been a difference of opinion as to the effects of annealing hoisting chains, some believing that it is beneficial while others assert that it is of little value. The work on which the report is based was carried out at the Carnegie Institute of Technology. The conclusions to which the committee come are, among other things, that chain used where failure may endanger human life or property should be annealed as often as careful inspection shows this to be necessary. Certain external indications and methods of determining when annealing is necessary are given. Wrought-iron chain for use in service where failure may endanger human life or property should be annealed under conditions that permit accurate measurement and control of temperature. However, because of the wide application of wrought-iron chain in industry, it often happens that chains become dangerously embrittled from service in plants or localities where there is not available a properly designed annealing furnace with pyrometric control. In such cases it must be recognized that the necessity of removing the dangerous brittleness is so imperative that annealing the chain under conditions differing from the ideal may be far safer than not annealing it at all. Nevertheless, because of innumerable instances where wrought-iron chain has been ruined or seriously damaged by improper annealing in mill furnaces, foundry kettles, blacksmith forges, open fires, etc., the committee cannot recommend the annealing of wrought-iron chain in any heating appliance which fails to permit the definite attainment of a uniform temperature in all parts of the chain, the definite control of temperature, and means for approximate determination of the temperature.

Some chains should be not only annealed but also normalized, and the temperature in normalizing should be under close control. The figures for the temperatures, etc., are given in the original report.

The greatest safety is desired in crane and sling chains which are used in carrying material over working men. It is recommended that, where possible, the repair and annealing of such chains be entrusted to a company making a business of this work and having the necessary experience, equipment, and technical supervision to do it correctly. As a matter of accident prevention this method is fully justified, being much safer than having the work done by local workmen and blacksmiths using furnaces, fires, or equipment not especially intended for the annealing and repair of chain, and perhaps seriously unsatisfactory for this purpose.

These recommendations are followed by a very interesting synopsis of established facts and principles bearing upon the problems of chain annealing which is recommended to all those interested in the matter.

Part 3 of the report contains a study of annealing of chain in relation to the effect of repeated loading. From this it would appear that absolutely no warning can be expected in case of fatigue failure of chains. Up to the very instant of failure there will be no change in the appearance of dimensions of any parts of the links, nor any diminution of strength which could be detected by a proof test in tension, or by any other known test.

In planning research tests on chain it is futile to adopt any program which depends on pulling tests to determine how much a chain has been weakened by service conditions or repeated loading.

Repeated-load tests on chain are briefly described.

Part 4 contains studies of the annealing of chain in relation to the removal of brittleness produced by surface impacting. This includes a description of laboratory methods of producing surface brittleness, and a discussion of tensile tests for measuring brittleness in chains.

Causes of general failure are discussed and certain principles laid down covering the surfacing and annealing of chains. (Harold A. Thomas, Carnegie Inst. of Technology, Pittsburgh, Pa., in *Transactions of the National Safety Council, 1930*, Report of Safety Congress, Pittsburgh, Sept. 29–October 3, 1930, pp. 281–323 and discussion, pp. 324–332, illustrated, *peA*)

Stresses in Boiler and Superheater Tubes

A CONSIDERABLE amount of work has been done recently in an effort to develop a method of computing stresses in boiler and superheater tubes. In 1928 Münzinger published a treatise calling attention to the high thermal stresses which occur in boiler tubes. Among other things he pointed out the fact that an increase of 1 mm. (roughly 0.04 in.) in the thickness prescribed for the first row of tubes in water-tube boilers by German regulations for stationary boilers does not increase the safety of the tubes. Later on in an investigation carried out by the Hanomag Company for the Technical Committee of the Water-Tube Boiler Association, it was shown for the first time that there are certain definite wall thicknesses at which the sum of the stresses due to internal pressure and heat expansion has a minimum value. The same conclusion was reached independently by Helfrich and by the German General Electric Company. However, the magnitude of the stresses and of the minimum values obtained were by no means the same in the various investigations. The investigation of the Hanomag Company was made on the assumption that the *average* thermal stress at the periphery of the tube is of basic importance in the determination of thermal stresses. On the other hand, Helfrich and the German General Electric Company assume that it is the *maximum* thermal load on the periphery that determines the thermal stresses. It is important to find out which one of these assumptions is correct, as the results obtained by using them vary in the ratio of one to three. Helfrich obtains very high stresses and comes to the conclusion that thermal stresses alone are sufficient to cause damage to the boiler tubes. The investigation of the German General Electric Company tends to indicate for the first time that when the elastic limit is exceeded a part of the stresses become equalized. The present

investigation was undertaken for the purpose of clarifying the situation with respect to stresses in boiler and superheater tubes. Only certain parts of this investigation can be here abstracted.

STRESS DUE TO INTERNAL PRESSURE

The author selected the absolute normal stresses as the basis of his computations. The total stress is found by adding the stresses produced by the internal pressure and those produced in the wall by the difference in temperature. The absolute normal stress in the circumferential direction in a hollow cylinder may be expressed by the formula

$$\sigma_y = \frac{p_i r^2_i - p_a r^2_a}{r^2_a - r^2_i} + (p_i - p_a)\frac{r^2_a r^2_i}{r^2_a - r^2_i} \times \frac{1}{z^2} \quad [1]$$

given by Bach-Baumann in "Elastizität und Festigkeit," 1924, pp. 571-578. Here p_i is the internal pressure, p_a the external pressure, r_i the inner radius, r_a the outer radius, and z any given radius. The maximum stress occurs at the inner fiber. With $p_a = 0$ and $z = r_i$ the stress due to internal pressure alone is expressed by

$$\sigma_p = p \times \frac{r^2_a + r^2_i}{r^2_a - r^2_i} \quad [2]$$

HEAT STRESSES

The formula for the calculation of heat stresses in a hollow cylinder given by Lorenz (*Zeitschrift des Vereines deutscher Ingenieure*, 1907, p. 743) states that the temperature in each circle of the cross-section of the tube is the same, which is equivalent to saying that the load due to temperature is the same over the entire periphery of the tube.

In the case of a boiler tube subjected to heat radiation this assumption does not hold good, so that the Lorenz formula cannot be used without some modification. A strict solution of this problem is scarcely possible because of mathematical difficulties, particularly if we consider that even for the case of uniform load none has so far been discovered. However, the author has found a different way to obtain a solution sufficiently precise for engineering purposes. Since thermal stresses bear a given relation to the temperature difference in the wall, it becomes necessary first to understand the laws of temperature distribution. For heat conduction in tubes only such solutions are available as are made on the assumption that the heat is uniformly distributed around the periphery of the tube. This problem has been solved elsewhere, the author states, but where he does not say. From that investigation it would appear that the temperature difference in the radial direction of the tube is not at all affected by conduction in the circumferential direction. Hence, even when distribution of the heat is not uniform the difference of temperature between the outer and inner wall can be computed by means of the following formula:

$$t_a - t_i = \frac{q \times r_a}{\lambda} \times \log_e \frac{r_a}{r_i} \quad [3]$$

where $t_a - t_i$ is the temperature difference in deg. cent.; q the heat load in kg-cal. per sq. m. per hr.; and λ the heat conductivity in kg-cal. per m. per hr. per deg. cent. difference.

The following may serve for the determination of the heat stresses in the case of non-uniform distribution of heat. It can be proved that if a curved bar with a radius of curvature ρ_0 is exposed to a flow of heat advancing in the direction of the radius its curvature will change to that represented by the following equation:

$$\frac{1}{\rho} = \frac{1}{\rho_0} + C \times q \quad [4]$$

where C is a constant. In this case the curvature of the bar consists of the original curvature and an additional curvature proportional to the heat load.

Let us now consider a tube so cut as to produce two symmetrical halves (Fig. 1). Because of symmetry it is sufficient to consider the behavior of one half only. If the heat load acts from the outside the tendency is to increase the curvature of the tube. If we now plot the additional curvature which we know is proportional to the heat load over the developed half of the tube circumference, we shall obtain such a diagram that as shown in Fig. 2. Inasmuch as the deviations from the original curvature are small, the additional curvature can be expressed by the formula

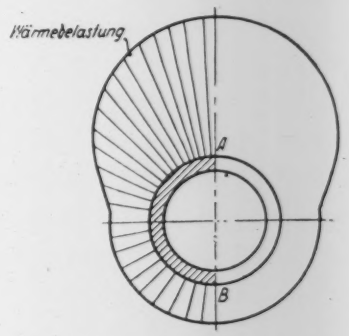

FIG. 1 TUBE WITH NON-UNIFORM HEAT LOAD

$$k = -\frac{d^2 r}{dx^2} \quad [A]$$

where k is the additional curvature. Integrating,

$$\frac{dr}{dx} = -\int k dx + C \quad [B]$$

The expression dr/dx gives the magnitude of the tangent to the bar after it has experienced the additional curvature. If the value of this tangent at A be set equal to zero the integration constant C disappears, but in order that the halves of the tube shall coincide, the tangent at B must be also equal to zero, hence

FIG. 2 ADDITIONAL CURVATURE PRODUCED IN ONE OF THE HALVES OF A TUBE BY HEAT FLOW

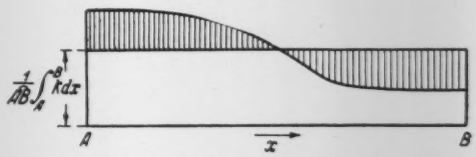

FIG. 3 ADDITIONAL CURVATURE OF THE TUBE CIRCUMFERENCE

$$\int_A^B k \times dx = 0 \quad [C]$$

This integral, however, can only be equal to zero when the zero line is located at the mean height of the figure (Fig. 3).

This means that in order that the two halves of the tube shall come together again it is necessary to produce an additional curvature by a uniformly distributed moment. This additional curvature has the magnitude

$$\frac{1}{AB}\int_A^B k dx \quad [D]$$

However, according to Bach-Baumann, p. 517, the equation

$$\frac{1}{\rho} = \frac{1}{r} + \frac{M_b}{E\chi f \times r^2} \quad [5]$$

applies to the case of bars with curved center line. In this expression M_b is the bending moment, E the modulus of elasticity, f the cross-section, and χ is a function of the radius of curvature and the dimensions of the cross-section. This formula is of the same type as Equation [4] above. The second term in the right-hand member is given by the additional curvature produced by the bending moment, and hence

$$M_b = E \times \chi \times f \times r^2 \times \frac{1}{AB} \int_A^B k dx \quad \ldots\ldots [6]$$

Since k is directly proportional to the heat load, it follows that the bending moment is proportional to the average heat load. This bending moment is uniform over the entire periphery of the tube. Hence the heat stresses as well as the bending moment are a function only of the average heat load and not of the maximum heat load. From Equation [6] the heat stress in the tube can be computed. The author, however, is satisfied with the fact that he has determined it is the average heat load that governs the calculation, and uses the Lorenz formula in what follows.

Total Stress

The Lorenz formula for calculating heat stresses in the circumferential direction at the inside fiber is as follows:

$$\sigma_w = \frac{m+1}{m-1} G \times \alpha(t_a - t_i)\left(\frac{2r^2_a}{r^2_a - r^2_i} - \frac{1}{\log_e r_a - \log_e r_i}\right) \quad [E]$$

If instead of the little-known modulus of elasticity in shear G, the expression

$$G = \frac{E}{2} \times \frac{m}{m+1} \quad \ldots\ldots [F]$$

is introduced, and if further instead of $(t_a - t_i)$ is introduced in Equation [3], then we obtain the absolute total stress σ_{total} in the inner fiber in the peripheral direction.

$$\sigma_{total} = p\frac{r^2_a + r^2_i}{r^2_a - r^2_i} + E\frac{m}{m-1} \times \alpha \frac{q \times r_a}{\lambda \times 2000}\left(\frac{2\,r^2_a \times \log_e \frac{r_a}{r_i}}{r^2_a - r^2_i} - 1\right) \quad \ldots\ldots [7]$$

Here q is the average heat load on the tube periphery in kg-cal. per sq. m. per hr.; r_a the outer radius in mm.; r_i the inner radius in mm.; E the modulus of elasticity in kg. per sq. cm.; m is Poisson's ratio; α the thermal expansion in mm. per deg. cent.; and λ the heat conductivity of the tube material in kg-cal. per m. per hr. per deg. cent. This formula applied to boiler tubes as well as to superheater tubes.

The Best Wall Thicknesses

The stresses as expressed by Equation [7] have a minimum value at certain predetermined wall thicknesses. If we introduce into this equation the expression $\beta = r_a/r_i$ and then differentiate the equation with respect to β and set the result equal to 0, we obtain the equation

$$\beta^2 - 2\log_e \beta - 1 = \frac{p}{d \times d_a} \times \frac{8000 \times (m-1)\lambda}{E \times m \times \alpha} \quad \ldots\ldots [8]$$

Table 1 gives an evaluation of this equation. It is necessary, however, that the expression $\frac{8000 \times (m-1)\lambda}{E \times m \times \alpha}$ be set equal to 6470.

TABLE 1 THE MOST ADVANTAGEOUS VALUES OF p/q IN UNITS OF 10^{-8} $\frac{\text{kg.} \times \text{m.}^2 \times \text{hr.}}{\text{cm}^2 \times \text{kg-cal.}}$

(*Wanddicke s in mm.* = wall thickness s in mm; *aussendurchmesser d_a in mm.* = external diameter d_a in mm.

Note: This table has been reproduced from the original German article, and the commas are therefore to be read as decimal points.

Wanddicke s in mm	Außendurchmesser d_a in mm										
	38,0	44,5	47,5	51,0	60,0	70,0	76,0	83,0	89,0	95,0	102,0
2,50	25,6	21,0	19,4	17,9	—	—	—	—	—	—	—
2,75	32,3	26,1	24,0	22,1	—	—	—	—	—	—	—
3,00	39,0	31,6	29,1	26,8	22,2	18,4	16,6	—	—	—	—
3,25	47,0	38,3	35,0	32,1	26,7	21,9	19,9	17,9	16,5	—	—
3,50	55,8	45,2	41,4	37,7	30,7	25,9	23,2	21,3	19,4	18,2	—
3,75	65,4	53,6	48,8	44,5	36,0	30,1	27,1	24,6	22,7	20,8	19,3
4,00	77,5	61,9	56,9	51,6	41,6	34,5	31,1	28,2	26,1	23,9	22,0
4,25	90,7	71,9	64,6	59,3	47,9	39,2	35,7	32,0	29,5	27,4	25,2
4,50	104,2	81,8	75,6	68,2	54,7	44,9	40,5	36,3	33,4	30,8	28,7
4,75	119,2	94,9	85,9	77,6	62,0	50,7	45,7	40,8	37,8	35,2	32,3
5,00	136,0	106,6	96,9	86,7	69,8	56,9	51,3	45,8	42,1	39,2	35,9
5,25	154,5	121,1	109,8	98,1	78,8	63,8	57,4	51,0	46,9	43,4	39,9
5,50	174,8	135,5	123,0	110,4	87,2	71,2	63,8	57,0	52,2	48,1	44,3
5,75	—	—	—	—	96,9	78,9	70,6	62,6	57,6	53,0	48,8
6,00	220,3	169,9	152,4	137,6	108,5	87,6	78,0	69,5	63,3	58,3	53,6
6,25	—	—	—	—	—	—	—	76,4	69,4	64,1	58,5
6,50	277,3	209,8	188,0	168,7	132,2	106,0	93,6	—	—	70,0	63,7
6,75	—	—	—	—	—	—	—	91,3	83,2	—	69,3
7,00	344,9	255,9	228,4	203,0	159,5	126,6	111,6	—	—	82,9	—

For a heat load of 100,000 kg-cal. per sq. m. per hr. the figures in the table give also the most desirable operating pressures. The publication of the German General Electric Company contains an approximate formula for the best wall thickness, namely,

$$s_0 = \sqrt{\frac{p \times d_a}{2 \times A \times q}} \quad \ldots\ldots [9]$$

and by properly selecting the value of the constant A the error is less than ± 10 per cent. All of the foregoing calculations assume that the material of the tube is perfectly elastic, which is not the case, however, when scale has formed. The author considers this condition in detail, but his findings cannot be given here because of lack of space. (Alfred Konejung, Düsseldorf, in *Die Wärme*, vol. 53, no. 48, Nov. 29, 1930, p. 891–895, 5 fig., *tm*)

FOUNDRY (See Special Processes: Pressure Die Castings of Aluminum Bronze)

FUELS AND FIRING

British Research on the Bergius Progress

SOME time ago the Fuel Research Board in England undertook to investigate the Bergius process. At first successful trials were made with British coals at the Mannheim Works of Dr. Bergius, and then a similar plant was erected at Greenwich. Some account of this work is given in an appendix to the recent report of the Board.

In this plant the operation is continuous, and also on a fairly

large scale, but the work on it has been supplemented by researches made on a smaller scale with bombs, in which, however, the reaction is necessarily an intermittent one, and is effected, accordingly, under less favorable and controllable conditions. Nevertheless, even under these adverse conditions, very promising results have been attained.

The yield of oil by the Bergius process may be regarded as satisfactory, but the crude product is a tarry liquid with a considerable content of water and solids in suspension. The latter can be got rid of in centrifugal separators, but the separated product is by no means oil-free. In distilling the crude product before removing the solid matter, trouble occurs from frothing and bumping. A great improvement has been effected at the research station by circulating the hydrogen in a continuous current over the fuel, and thence through a condenser in which the volatile products are continuously separated out. The oil obtained in these conditions differs, it is stated, most markedly from the normal Bergius product. It is dark red-brown in color, quite clear, transparent in thin layers, and free from solid matter. The residue left on distillation up to 360 deg. cent., moreover, is not pitch, but a thick, heavy, waxy oil. The conclusion reached, as the result of this improvement, was that it should be possible to obtain 120 to 130 gallons of spirit per ton of coal treated.

Possibly even more important is the discovery that tars, whether from low- or high-temperature plants, can be almost wholly converted into spirit and oil by hydrogenation in the presence of suitable catalysts. In the case of low-temperature tars, the fractions boiling below and above 230 deg. cent. were treated separately. In the case of the less volatile fraction, the best results were obtained when the temperature was 450 deg. cent. and the hydrogen was supplied at a pressure of 1500 lb. per sq. in. Using molybdic acid and sulphur as a catalyst, the result was an amber-colored, sulphur-free oil, all of which was completely soluble in light petroleum, and which contained, accordingly, no pitch. Although the process was an intermittent one, 78 per cent of the charge was converted into neutral oil, and still better results are expected from a new plant which is now being erected, in which the process will be continuous.

The fraction which boiled below 230 deg. was similarly treated, but the catalyst was simply molybdic acid. In this case, the whole of the tar acids were converted into neutral oil, all of which boiled below 170 deg. cent. The spirit obtained after distillation required no further refining. In further experiments, the hydrogen was supplied at atmospheric pressure, the catalyst being a mixture of molybdic acid and active charcoal, and the yield of neutral oil was equal to 80 per cent of the theoretical. From these results it is estimated that, with suitable plant, the 20 gallons of tar commonly obtained in the gasification of coal could be made to yield 16 gallons of motor spirit and 4 gallons of neutral oil, boiling between 230 deg. and 360 deg. cent.

Another interesting discovery, which may lead to important industrial developments, was that almost all coals could be converted into a pitch-like material by merely heating the dry coal to a suitable temperature in an atmosphere of hydrogen, under a pressure of 1500 lb. per sq. in. The industrial prospects of all these processes are of course adversely affected by the fall in the world prices for oil fuel, which are now only one-fifth what they were ten years ago. The hydrogen required is expensive, but a high degree of purity is now obtained with the Lane-Rogers hydrogen plant, average samples being 98.4 per cent pure. (Report of the Fuel Research Board for the year ending March 31, 1930; abstracted through *Engineering*, vol. 131, no. 3390, Jan. 2, 1931, p. 18, *e*)

HOISTING MACHINERY

Two Elevator Cars in One Hoistway

THIS arrangement has been adopted in the new office building of the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., with each elevator running at 600 ft. per min. A floor-button system of control is used and the cars are full-automatic in operation. At each landing are two sets of buttons for calling either the upper or lower car. The top car operates from the third to the eleventh floor, and the bottom car from the first to the ninth floor. Sufficient head room has been provided to park the upper car during inactive periods of the day and permit the lower car to serve ten floors.

When running two elevator cars in the same hoistway the question of safe operation becomes uppermost. Obviously both cars should run in the same direction on a fixed schedule, and it is necessary to arrange them so that, in simple language, one car will not bump into the other.

The cars are normally operated on a block system of control similar to that for subway trains. When one car approaches the other, it is first slowed down and then stopped by the same control that is used for its normal operation. The operator has a set of three signal lights. A green light indicates that the car can run full speed; an amber light is a caution signal requiring half-speed; a red light means stop. These three lights guide the operator and indicate one car's position in relation to the other.

Differential gearing at the top of the hoistway is provided with two elements, one of which is attached to each car by a steel tape. Automatic devices stop both cars if either steel tape becomes slack. The differential gearing indicates the relative positions of the cars, and operates to slow down and stop the approaching car if the block system fails. The action is selective, and the leading car does not have its control interfered with. Every facility is provided for the leading car to clear the block and provide safe running space for the following car. The speed of the approaching car is reduced and the car finally stopped in three stages by the differential gearing.

The two counterweights are operated on the same set of rails, and the upper is provided with a safety to prevent its dropping on the lower counterweight in the event the ropes break.

The car safety is a recent improved design. It is set by a very small movement of the car after the governor trips. The initial pressure of the jaws against the rail is applied with a spring. A further movement of the car causes the jaws to grip the rail with increasing force. If the ropes remain intact it is probable that the first application of the safety will bring the car to rest without a severe strain on the passengers.

A diagram in the original article shows the roping of the machines and the arrangement of the compensating ropes and electrical cable connections. Aluminum was used wherever reduced weight improved operation. A combination of aluminum and micarta gives the car enclosures an unusual and attractive appearance, while the saving in weight of the cars and slings is large. This initial installation has developed many interesting engineering details that have led to improvements in operation. Experience shows that fewer safety devices will be sufficient, but when a new departure of this kind is undertaken it is desirable to be on the safe side. Dual elevators are safer in operation than the ordinary single elevator. Some of the safety devices introduced on this installation are applicable to single elevators, and many prove desirable on high-rise, high-speed installations, many of which are now being built. (H. D. James, Consulting Control Engineer, Westinghouse Electric & Mfg. Co., in *Power*, vol. 73, no. 3, Jan. 20, 1931, pp. 100–103, 7 figs., *d*)

INTERNAL-COMBUSTION ENGINES (See also Power-Plant Engineering: German Progress Report for 1930)

The De La Vergne and M W M-Benz High-Speed Diesel Engines

THE De La Vergne engine built by I. P. Morris and De La-Vergne, Inc., is of American manufacture, and with a bore of 9 in. and stroke of 11 in. is rated at 300 b.hp. at 750 r.p.m. in the six-cylinder unit. It is claimed that the rates of fuel consumption correspond to 0.40, 0.41, and 0.44 lb. per b.hp-hr. (D.E.M.A. specification) at full, three-quarters, and one-half load.

One of the interesting features of the new engine is the airless-injection combustion system. The shape of the combustion chamber is defined by a flat-top cylinder head and a conical, slightly shrouded piston whose contour is such as to concentrate the combustion air in the paths of the several fuel jets. The spray valve is concentrically located directly above the rounded point of the conical piston, while the greater portion of the combustion air is situated more toward the periphery of the piston whose crown is depressed in this region. This construction permits the clearance needed for a compression ratio of 13:1 (420 lb. per sq. in.) without resorting to an excessively flat combustion chamber. It is a principle of modern Diesel-engine design to have combustion-space contours corresponding to the natural shape of the airless-injection fuel sprays. The spray valve is of the differential needle type made by the Robert Bosch Magneto Co., and is timed and operated without valve gear by means of an individual Bosch injection pump. The Bosch fuel pump is described in detail in the original article. One such pump is mounted in front of each cylinder. Four valves are fitted to each cylinder head in order to provide the cross-sectional, area corresponding to a piston speed of 1375 ft. per min. The designer in making this arrangement apparently had at least two additional objects: The four valves are reported to be located in such positions that the cored intake passages in the cylinder heads leading up to them cause rotation of the air charge in the cylinder. At the same time the air passages connect with the cored space situated in the cylinder beam between adjacent cylinders, and the problem of connecting them with the manifold on the same level and on the same side of the engine as the exhaust manifold is avoided. This matter of location of the valves is further discussed in the original article.

An interesting feature is the relatively low ratio of cylinder center distance to cylinder bore, this being 14.5:9 or 1.6. Low ratios of this order are looked upon as a growing feature of light-weight high-speed engines, in view of the stiffness which they impart to the crankshaft and of the resulting reduction in engine weight and length. Short, rigid main bearings have been found to give actually lower net bearing pressures and consequently better running than longer and more flexible journals. Although the latter permit of calculating a lower specific bearing pressure, they actually seem to bear harder on localized areas of the bearing near the edges on account of their greater bending. In the engine under consideration such effects have been further guarded against by the use of crankshaft journals whose diameter bears a high ratio to the cylinder bore, and which is therefore considered to be exceptionally stocky.

The M W M-Benz is an engine of the high-speed automotive type with precompression chamber, and was primarily developed at the request of the German Navy for use on fast auxiliary boats. It is a four-stroke-cycle vertical engine with six or eight cylinders of 8.07 in. bore and 10.63 in. stroke, running at 800 to 1000 r.p.m. and developing in the six-cylinder unit 250 b.hp. at the lower speed and 300 at the higher speed with a weight of 6170 lb.

Each cylinder has its own cylinder head, inside of which is located a precombustion chamber with fuel valve and atomizing thimble as well as the inlet and exhaust valves. As the precombustion chamber is eccentrically located with respect to the cylinder center line, it is possible to keep the valves so large that good volumetric efficiency is assured even at the high rotative speed used.

The fuel pumps for all the cylinders are united in a common block fastened to the front end of the engine and are driven from the camshaft by means of helical gears. They are regulated in the usual manner by interrupting the discharge stroke, which occurs at a point of time set by the governor through the opening of a spill valve short-circuiting the discharge with the suction chambers. Motion for the spill valve is derived from a drag link, one end of which moves with the pump plunger, while the center of the opposite end is eccentrically pivoted on the regulating shaft and is raised or lowered by the latter.

Alteration of the timing of the start of injection is effected by axially shifting the helical tooth outlines of the gears, in consequence of which the driven one is rotated relatively to the driver. In order to permit varying the quantity of fuel independently of the governor, a spring member is inserted in the regulating linkage so that the governor shaft may be positioned over a sector by means of a hand lever. A duplex lubricating-oil filter is used; it contains two valve-controlled strainer baskets, each of which is made of a system of fine-mesh concentric cylindrical screens. The filtering chambers are connected by cored passages in such a manner that they can be alternately connected by means of a cock to permit of removing and cleaning one strainer basket at a time while the engine is running.

It is claimed that the fuel consumption is about 0.436 lb. per b.hp-hr. Curves in the original article would indicate as a characteristic of the engine the constancy of its torque over the entire range of operating speeds. (*Diesel Power*, vol. 8, no. 12, Dec., 1930; article describing the De La Vergne engine on pp. 622–624, 3 figs.; article describing the Benz engine on pp. 626–628, 6 figs., *d*)

MACHINE-SHOP PRACTICE

Experiments on the Cutting of Metals

WHEN metal is cut in the usual manner by a lathe tool, the tool deflects elastically very little. The cutting force exerted on the tool is proportional to the deflection of the tool. Figs. 1 and 2 in the original article show the new arrangements for measuring the deflection of the tool by Marten's mirror. Using this method, the experiments were made upon mild steel; cutting angle, depth of cut, shape of tool, and lubricant were also examined, and the flow of the metal was studied by microscopic examination of cross-sections taken through the chip in process of formation.

The following results were obtained:

a When the deformed zone is formed on the cutting edge, the cutting is in the most favorable condition and its formation depends on the nature of the work material, cutting speed, cutting angle, and depth of cut.

b The cutting force and cutting temperature are minimum when the shape of the tool is such as to make the chip flow most easily.

c The relation between the cutting speed and the cutting force is not simple, but varies with the kind of work materials, cutting angle, and depth of cut.

d The rapid change of cutting speed is to be explained by the change of the separating manner of the chip.

e The smoothness of the work surface depends on the manner in which the chip separates and on the sharpness of the deformed zone. (Shizuo Doi in *Journal of the Engineers Association of Manchuria*, vol. 7, no. 37, 1930; also in *Publication No. 4 of the Ryojun College of Engineering*, 16 pp., 19 figs., with brief bibliography. Original publication in Japanese, *e*)

NATIONAL DEFENSE

Control of Industry in War

FROM this address it would appear that the U. S. War Department is developing a plan under which the industry of the country may promptly begin the manufacture of the munitions the Army will need initially in a major war, and a constructive and comprehensive plan under which the Federal Government may mobilize the country's industrial and economic assets into one coordinated team to assist in the prosecution of the war.

This is done by the War Department's carefully determining the amounts of all items that would be necessary under any given strategic situation. The supply services then determine in detail what industrial establishments will be required to begin producing these items upon the outbreak of war.

Intensive study has been made concerning the effect to be expected on the industrial and economic life of the country by the transition from a state of peace to that of war by the demand set up by the Army and Navy munitions program. The question of providing an adequate organization to control industry in war is one of the most important and at the same time one of the most difficult today. In general, the plan proposed by the War Department follows that of the War Industries Board of 1917–18.

In 1917, Army, Navy, and other officials had very little conception of the immediate munition needs of our fighting forces. Contracts for some items were immediately placed far in excess of requirements, while other essential items were initially neglected. Some manufacturing plants were swamped with war orders, while others were given none. Government purchasing agents competed among themselves for the output of industrial establishments. As a consequence prices rose rapidly to higher levels, and the making of large profits by some concerns was unavoidable. Finally drastic reorganization become necessary.

Contrast that experience with what we visualize will happen in the event of another war. Under the procurement plan, military items will be contracted for only in the amounts deemed necessary, and wasteful use of productive capacity will thus be avoided. The production load will be spread over the entire country, and congestion in particular sections will not occur. There will be no competitive bidding between purchasing agents, because each has been allotted specific plants with which to deal, and thus one great cause for mounting prices will not exist. Finally, since each plant to which has been allotted war work is warned in time of peace of the exact task it will be expected to perform, production of essential munitions can begin with the least possible delay.

Other interesting and most perplexing problems are encountered in attempting to devise a complete plan for the control of our industrial life in war. Among these are determination of priorities in production; preparation of conservation programs; devising plans for the control of finances; and the development of methods for the regulation of prices in war. If time permitted it would be most interesting to discuss some of these in detail, particularly methods for the regulation of prices. The satisfactory solution of this problem is a prerequisite to success in eliminating profiteering and in distributing equitably the burdens of war. (Address by Frederick H. Payne, Asst. Secy. of War, before the members of the Army Ordnance Association, at the Business and Technical Section, 12th Annual Meeting, Washington, D. C., Oct. 8, 1930; abstracted through *Army Ordnance*, vol. 11, no. 63, Nov.-Dec., 1930, pp. 181–182, *g*)

POWER-PLANT ENGINEERING (See also Engineering Materials: Stresses in Boiler and Superheater Tubes)

Effect of Excess Air in Chain-Grate-Stoker Operation

TESTS described in this article indicate that it is not generally true that an increase in excess air above the minimum consistent with good combustion of the gaseous products will result in an increase in stack losses greater than the decrease of the ashpit losses.

From these tests it would appear that both for coking-plate-type stokers and for stokers without coking plates the best results were obtained with a heavy fire and slow grate speed; excess air should be kept low and the coal should not be tempered. For coking-plate stokers no gain is made with tempered coal. With wet coal there is a greater tendency for the fuel to feed irregularly from the coking plates, so that any benefits that might be derived from the coal are lost because of unevenness of the fuel bed, through which holes are burned.

The original article gives a proximate analysis and fineness grading of the coal used in tests. This coal was tempered to about 9 per cent moisture, which had previously been found to give best results, and with this particular coal the best operations for the type of unit used in the tests are to be had with 40 per cent excess air and a fuel-bed thickness of 7.5 to 8.0 in. The results with 40 per cent excess air were better than with 60 per cent, presumably because of zone control of the fuel bed.

Coals with different fineness-grading or clinkering characteristics, however, can be expected to show different results. (E. C. Cawrse, Cleveland Electric Manufacturing Co., Cleveland, Ohio, in *Power*, vol. 72, no. 27, Dec. 30, 1930, pp. 1042–1043, 6 figs., *ep*)

German Progress Report for 1930

THIS is the report prepared by the German Society of Engineers. In the field of steam research the Government Scientific Bureau (Reichsanstalt) carried out tests on the heat of vaporization and the volume of saturated steam up to 310 deg. cent. (590 deg. fahr.) and 100.7 atmos. (1432 lb. per sq. in.).

In the Munich Laboratory for German Physics, W. Koch determined the specific heats of superheated steam up to 200 atmos. (2844 lb.) pressure and 370 deg. cent. (698 deg. fahr.) The U. S. Bureau of Standards has completed the measurements of practically all the characteristic properties of saturated steam up to 270 deg. cent. (578 deg. fahr.) and 56.1 atmos. (800 lb.). The Massachusetts Institute of Technology has published the recent measurements of saturation pressures up to the critical point as well as the magnitudes in the superheated-steam range up to 44 atmos. and 330 deg. cent. (725 lb. and 626 deg. fahr.). The results of the most recent investigations were presented in the form of a steam table by Keenan, but in English units only. On the other hand, the Second International Steam Table Conference which met in Berlin in June, 1930, published its steam tables in German technical units, retaining, however, the international kilo-calorie (according to the definition equal to 1/860 international kw-hr.) first recommended at the London Conference in 1929. The values of specific volumes of steam up to 270 atmos. and 400 deg. cent. (752 deg. fahr.) have been collected for purposes of steam measurement by the Associated Dye Industries (I.-G. Farbenindustrie). Henning and Justi have

computed the relation of the specific heats of various gases to each other (air, nitrogen, carbon dioxide, water vapor) at temperatures up to 1350 deg. cent. (2462 deg. fahr.) doing this on the basis of the theory of oscillations of atoms in molecules. The close correspondence of these values with the results of measurements of the Reichsanstalt carried out in 1905 and 1907 may be considered as support for this theory.

In the field of heat-transfer research a number of valuable new investigations have been published by the engine laboratory of the Technical University of Danzig dealing particularly with heat transfer between vertical plates and still air, heat transfer through cylindrical layers of gas (W. Beckman), and condensation in the form of film and globules.

Considerable attention was attracted at the Karlsruhe meeting of the Thermal Research Board of the German Society of Engineers to tests carried out by E. Schmidt on radiation in the neighborhood of a heat-emitting body. Jakob, Eck, and Erk reported on a remarkable anomaly noticed in the condensation of superheated steam and its relation to the problem of turbulence. Finally may be mentioned an investigation on the heat conductivity of a large number of fireproof building materials at temperatures of from 100 to 1000 deg. cent. (212 to 1832 deg. fahr.) carried out by the glass-technology laboratory of the Osram Company.

Steam Boilers and Furnaces

The increase in output and reliability of boilers and furnaces is having an important influence on the technical design and economy of operation of modern power plants. This in turn has attracted increased attention to such problems as the selection of proper materials of construction, feedwater, water circulation, unity in design of boilers and furnaces, and their regulation and methods of operation. Outputs of 500,000 kg-cal. per sq. m. (184,400 B.t.u. per sq. ft.) per hour have been obtained not only with radiant-type boilers and powdered-fuel firing, but recently also in Stirling-type and inclined-tube-type boilers with grate firing.

The important matter of heat transfer has not yet been quite thoroughly investigated, with the result that there is still a certain amount of uncertainty as to the calculation of heating surfaces, particularly in the case of superheaters. As the sizes of turbines increase, there is naturally an increase in the size of boilers and furnaces. The largest boilers installed up to the present in Germany have a heating surface of 2400 sq. m. (25,830 sq. ft.) and a maximum continuous output of 150 tons of steam per hour. Superpressure boilers as yet have been installed in only a few plants, where the economic conditions are particularly favorable. The majority of newer boilers are being built for an operating pressure of from 20 to 45 atmos. (285–640 lb. per sq. in.), and only a few exceed those pressures. In the matter of employing higher temperatures there is also a certain amount of conservatism exhibited, the majority of recently installed boilers operating at from 350 to 450 deg. cent. (662 to 842 deg. fahr.).

As the boilers have increased in size, so have the grates. The largest traveling grates hitherto built have an area of 50 sq. m. (538 ft.). Underfeed stokers go up to 65 sq. m. (700 ft.) with a grate load of from 1.6 to 2.3 $\times$ 10^6 kg-cal. per sq. m. per hr. This has been made possible by the extensive use of furnace water walls and by employing first-class materials of construction.

Underfeed stokers have been installed in Germany as yet in only a few of the very large central stations, and it is too early to arrive at definite conclusions as to their operation. "Return" grates (Martin grates, Fig. 4) have been successfully employed for the combustion of low-grade fuels, including brown coal or lignite. This has been made possible by improvements in their construction, by use of high-grade chromium steel for the grate bars, and by cooling of the furnace walls. Fuels of medium heating value can be also burned on these grates.

Progress in pulverized-coal firing has been lately materially retarded by the rise in prices of the types of coal suitable for this purpose. If one considers the cost of preparation, there is no price advantage today in favor of pulverized-coal firing as compared with grate firing. However, recent tests dealing with the flexibility of pulverized-coal firing have shown the great advantage of this method in the handling of variable loads.

With grate firing a large amount of flexibility may also be obtained, particularly when underfeed stokers are used. This development would indicate that in the future reserve units will be dispensed with and peak loads will be handled as a rule by overloading the boiler and generator plant.

Steam Engines and Turbines

The point at which the reciprocating steam engine can successfully compete with the steam turbine has been moved upward by the employment of steam at higher pressures and temperatures due to the fact that the lowering of the efficiency of the turbine with an increase of initial pressure (because of the smaller volume of steam) takes place more rapidly than do troubles in the operation of the reciprocating steam engine due to increase in the initial temperature of the steam. However, the development of steam-machinery building is today chiefly governed by the progress of very large steam turbines.

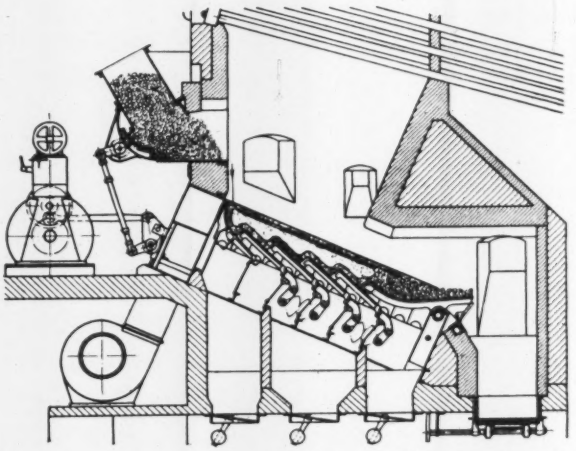

FIG. 4 MARTIN RETURN-GRATE STOKER FOR BURNING LOW-GRADE FUELS AND LIGNITES

In these latter the limits of output and the permissible increase of pressure and temperature are governed practically exclusively by the behavior of the materials employed in their construction. In this connection, among other things, the resistance of materials to creep still needs careful investigation. Other limits to the increase of output of turbines arise from the design of the casings and the number of stages employed. These matters today are influenced in part by costs, floor space available, etc. The largest single-shaft steam turbine in existence today is the 160,000-kw. unit in the East River station in New York, while the largest multi-shaft turbine is the 208,000-kw. unit in the State Line station near Chicago. The former of these runs at 1500 r.p.m. and the latter at 1800. In the development of large high-speed turbines, Europe leads. The largest single-shaft machine of this kind runs at 3000 r.p.m. and generates 50,000 kw., and a 60,000-kw. unit is under construction. The high initial pressure of 200 atmos. has been specified for a turbine which the B. B. C. (Brown Boveri Company?) is to build

for the central station at Langerbrugge to work with a Benson boiler built by the Siemens-Schuckert Works, while the high initial temperature of 538 deg. cent. (1000 deg. fahr.) has been specified for a 10,000-kw. unit to run at 3600 r.p.m. which is now being built by the British Thomson-Houston Company for the Detroit Edison Company.

Steam-turbine installations operating with an initial steam pressure of about 100 atmos. have been in successful operation in Germany for some time. Both here and in the United States the usual method of steam generation has been retained, which is a good indication of the progress made within recent years in steam-boiler construction. Of particular interest is the back-pressure installation built by the German General Electric Company for 115 atmos. and 475 deg. cent. (887 deg. fahr.) for the Renate mine of the Isle Mining Company, which is the first attempt to utilize the large amounts of waste energy which are made available by increasing the pressure and temperature in the heating steam of the briquet factory.

Of interest also is the attention which has been recently given to the Ljungström radial turbine, while the hope of making a gas turbine that will work has not been entirely abandoned. According to a communication made by Langer at the Second World Power Conference in Berlin, a 2000-kw. experimental installation of the Holzwarth type is to be placed in service; in this installation the working fluid will be cooled by water in the explosion chamber itself, and the heat thus salvaged will be utilized in a steam turbine. W. G. Noack has proposed a combination of a gas-power and a steam plant in which the combustion gases of a pressure-fired steam generator will be compressed by a blower driven by the exhaust from a gas turbine.

INTERNAL-COMBUSTION ENGINES

In general the same tendencies have prevailed as in 1929, namely, efforts have been made to obtain the largest output per unit, increase of speed, reduction of weight, elimination of valve-gear rods, and resort to compressorless injection as applied to large outputs. The two large M.A.N. compressorless Diesel motors installed in the Hennigsdorf central station have shown that high speed can be combined with a high thermal and mechanical efficiency. The fuel consumption is 177.5 gr. (0.39 lb.) per brake hp-hr. The mechanical efficiency is 92 per cent at a useful output of 12,000 hp. With the experience obtained in building these two engines, the M.A.N. concern is now in a position to undertake with assurance the construction of engines of up to 25,000 hp. in a single unit.

As regards marine Diesel engines, both the M.A.N. Company and Sulzer Bros. now use airless injection on large two-stroke-cycle engines. Sulzer Bros. have adopted the double-acting principle for two-stroke-cycle machines, while the M.A.N. has standardized for this type of engine on cylinders of 600 mm. (23.6 in.) bore and 900 mm. (35.4 in.) stroke, obtaining variations in output by varying the number of cylinders and engine speed. Both concerns use for these compressorless engines reciprocating scavenging pumps driven from the main shaft.

A new design of double-acting marine engine of the German Works has been simplified by having the upper and lower cylinder heads made in the same way. On the top, instead of the piston-rod bushing, is installed a starting valve. In the new single-acting two-stroke-cycle marine Diesel engine of the Krupp Germania Shipyards a suspended reciprocating scavenging pump is driven from the crosshead of each cylinder. In this connection it is stated that more and more use is being made of the process invented by Director Bassler of the German General Electric Company for brazing complicated machine parts subjected to high thermal and mechanical stresses. Reference is made to the engines of the British motorship *Britannic*.

A distinct advance in the development of locomotive drive by Diesel engines has been made through the tests of the 1200-hp. Diesel compressed-air locomotive on the German State Railways, but further tests will be required to determine the most advantageous method of transmitting energy from the motor to the driving axle. In the Junkers-Ansaldo locomotive an attempt is made to solve this problem through rigid connection of the motor with the drivers.

A three-stage compressor delivers the air for injection and starting. The application of Diesel engines to automotive vehicles and aircraft has progressed particularly well. The leadership of Germany in this field is attested by numerous licenses taken out by foreign concerns. Thus, for example, the M.A.N. automotive-type engine is now regularly installed on Fowler motor plows, and the Mercedes-Benz has also found extensive application outside Germany.

The Junkers aviation Diesel engine passed the standard tests of the German aircraft administration and is listed among the approved types. Its output has now been increased to 800 hp., while the aviation-type Diesel engine of the Packard type has given a continuous output of 225 hp.

The extension of long-distance pipe lines and the improvement of gas generators for fuels of low heating value have helped materially in extending the employment of gas engines in comparatively small plants. Where both power and heat are required the gas engine can compete up to a certain point with a steam plant because of the possibility of its utilizing the exhaust gases and jacket water for heating purposes.

In the field of research, attention is called to an investigation of the starting process in Diesel engines. This has shown that even at full load the engine can be started with compressed air. The phenomena of scavenging and charging in two-cycle motors have been investigated by K. Neumann, O Klüsener, and others, for Diesel engines and producer-gas engines. Furthermore an investigation on the oscillations in suction and exhaust piping may be mentioned here. The torsional cyclic vibrations which are particularly dangerous in the case of high-speed engines can be now made innocuous over a wide range of speeds by the application of dampers. Quite recently a mathematical analysis of the entire machine system, namely, the cylinder, frame, baseplate, and foundation, has been made with respect to vibrations due to bending. It has been found that these are apt to occur in tall marine engines equipped with a narrow baseplate. (Heat-engine section of a review of engineering in 1930, published in *Zeitschrift des Vereines deutscher Ingenieure*, vol. 75, no. 1, Jan. 3, 1931, pp. 5–7, 1 fig., *d*)

RAILROAD ENGINEERING

The Railroads in 1929

THIS abstract is made from a publication issued by the Committee on Public Relations of Eastern Railroads in New York City, and gives comparative figures for the years 1911 to 1929. Only some of the main facts are reported here. The operating mileage has gone up from 362,824 miles in 1911 to 428,200 miles in 1929, with the result that one-third of the world's mileage is located in the United States today. The number of passenger-train cars in service has gone up, while the number of freight cars has declined. This latter, however, has been accompanied by a great increase in average freight capacity—from 36.9 tons in 1911 to 46.3 tons in 1929—with the result that notwithstanding the decrease in the number of freight cars, the total freight-car capacity shows an increase of 35 per cent over 1911.

The number of locomotives in service has declined very slightly from 1911, but the power has gone up tremendously, the average

tractive power per steam locomotive in 1911 being 28,305 lb. and in 1929, 44,798 lb. This means heavier trains with fewer cars and locomotives in service. Enormous amounts running into billions of dollars have been spent for the improvement of railroad plant since 1911 in the way of new mileage and reconstruction of old mileage, as well as for new rolling stock and much old and obsolete equipment has been retired. The total property-investment accounts of the Class I railroads in the United States, including their investment in road and equipment, cash and material and supplies, amounted to $25,870,122,983 at the end of 1929, as compared with a little less than $15,000,000,000 in 1911.

The volume of operation of railroads in the United States may be judged by the fact that in 1929 on an average more than one million cars were loaded each week, which means that on an average, counting in all Sundays and holidays, 144,630 cars were loaded with revenue freight each day. The total tonnage transported in 1929 was almost two and a half billion tons, while the number of ton-miles runs into the nearly astronomical figure of more than 447,000,000,000.

The picture becomes less encouraging when we come to passenger service. Unlike the freight traffic, the passenger business of Class I railroads has been declining in recent years due to competition of the motor bus and the private passenger automobile. The result is that a number of passengers carried by Class I lines decreased in spite of the growth of population from 938,000,000 in 1911 to 780,000,000 in 1929. In passenger-miles the traffic reached its peak in 1920, with a total of nearly 47,000,000,000, and come down to 30,000,000,000 in 1929, which compares not unfavorably with 32,000,000,000 in 1911, and would indicate that the short-distance traffic was very severely affected by the competition of gasoline vehicles, as would be natural to expect.

In this connection it is interesting to note that passenger losses since 1921 have been confined to day coaches. The revenues received from passengers in sleeping and parlor cars having actually increased since 1921 while the estimated revenues have fallen off more than 40 per cent.

Rates in freight traffic are said to have declined since 1921, but are still at a higher level than in any year preceding 1921. It is not quite clear, however, why 1921, which showed the highest level reached in recent years and was an unusual year, is taken as the basis of comparison.

Gross revenues of Class I lines increased 128 per cent from 1911 to 1929, but at the same time, because of higher prices for goods and higher wages, the operating expenses of the roads jumped 137 per cent.

While operating expenses have outdistanced revenues, relatively, since 1911, the increasing efficiency and economy of railway operation in recent years have brought fruitful results. For example, from 1922 to 1929 operating revenues increased 13 per cent, while in the same period expenses increased only 2 per cent.

The number of locomotives in bad order in the years following the war was very high. Beginning with 1923, however, the efforts of the railways to improve the condition of their motive power began to show definite results, and by 1927 the figure was reduced 16.1 per cent as compared with 24 and 25.5 per cent in 1921 and 1922. There were slight increases in 1928 and 1929. The condition of freight cars also shows material improvement since 1920.

An important factor in the present improved railway service is the increase which has been made in the number of miles which each freight car, on the average, runs each day. In 1929, each freight car on the railway lines, on the average, traveled 32.4 miles each day, as compared with a daily average of 25.1 miles in 1920. This figure includes not only those cars actually moving, but also the cars being loaded and unloaded, the cars undergoing and awaiting repairs, and the surplus cars for which no load was available.

Because of this increased average daily movement, each freight car on the lines of the Class I railways performed, on the average, 10 per cent more work each day in 1929 than in 1920. The average freight car each day in 1929 performed a transportation service equal to hauling 547 tons of freight a distance of one mile. The corresponding average daily service performed in 1920 amounted to 498 ton-miles. This increase in average daily mileage is due to a decrease in the average load per car, a factor over which the railways have little or no control.

One of the records made by the railways in 1929 was in the use of fuel in the freight service. In the year 1920, it took 197 lb. of coal to move 1000 tons of cars and freight for the distance of one mile. In 1929 this same amount of work was done with only 142 lb. of fuel, representing a saving under 1920 of 28 per cent. The following figures show the amount of fuel used in recent years by the Class I railways in moving 1000 tons of cars and freight the distance of one mile; weight of locomotive and tender is not included. Every year shows an improvement over 1920, the best record being in the year just ended:

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veloped. A number of macro- and micro-photographs are given in the original article.

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SPECIAL PROCESSES

Manufacture of Insulating Board From Cornstalks

THIS publication gives detailed data about the location and quantities of cornstalks available, the physical and chemical composition of the stalks and parts thereof, and the methods and costs of harvesting and baling the stalks and delivering them to the factory. It also describes the experimental work in the manufacture of this material, together with such related subjects of research as refrigeration board, waterproofing, and fireproofing.

The general description of the process is given from which it would appear that the stalks first pass to a magnetic separator where any tramp iron present is removed; they are then shredded to proper size and delivered to beaters, where the stalks with addition of water are beaten into a pulp. The stuff with additions of alum and rosin is then pumped to the mat-forming machine, from which it goes to the press rolls of the board-forming machine. A list of equipment that will be required for commercial production is given, together with a detailed estimate of costs as well as expected uses for this material. (O. R. Sweeney and W. E. Emley in *Bureau of Standards Miscellaneous Publications*, no. 112, Oct. 18, 1930, 27 pp., 12 figs., some on separate inserts, *dp*)

Pressure Die Castings of Aluminum Bronze

A NOVEL application of die-casting practices has been developed by the Aurora Metal Co., Aurora, Ill. The company manufactures pressure die castings of aluminum bronze, which are cast at temperatures of about 2300 deg. fahr.

On account of the uniform accuracy to which it is claimed these castings are made, they require a minimum of machining, and in many cases no machining at all. The tensile strength of this material as cast is 85,000 lb. per sq. in. It has a hardness of Rockwell 66 B, Brinell 140. When quenched from 1700 deg. fahr., the tensile strength is 100,000 lb. per sq. in., and the hardness 110 Rockwell B, 260 Brinell. Any desired hardness between these limits can be obtained by proper heat treatment.

These die castings also have a high tensile strength at elevated temperatures. Die-cast test bars showed the following results at temperatures indicated below:

Temperature, deg. fahr.	Tensile strength, lb. per sq. in.
70	84,800
400	66,800
550	59,000
800	40,300
1000	19,000

The aluminum bronze having the above properties has the composition: 89 per cent copper, 10 per cent aluminum, and 1 per cent iron, By making slight variations in the composition of the alloy, changes can be effected in the physical properties of the die castings to suit particular requirements.

The corrosion resistance, absence of aging changes, resistance to shock, and great tensile strength claimed for aluminum bronze, should make its use advisable where any of these qualities would be advantageous. (*The Iron Age*, vol. 127, no. 5, Jan. 29, 1931, p. 405, *d*)

Steel Grit for Sand Blasting

THE article here abstracted reports tests on blasting made with alundum silica sand and commercial steel grit. Two hundred pounds of each material were used, and the number of pieces of work blasted before the 200 lb. were exhausted was noted. It was found that the silica sand broke down at 4700 pieces and the alundum at 20,000, while steel grit ran in excess of 80,000 pieces. On the other hand, sand costs $6 a ton, including freight charges, and steel grit, $100. Practically no dust was visible in the cabinets with steel grit.

There are several other advantages of steel grit. Thus, with sand it was necessary to clean the screen separator on the exhaust system twice a week, whereas with steel once in three months suffices. The saving in labor from handling 16 tons of steel grit a year against 330 tons of silica sand is also appreciable.

There were also other advantages derived from the use of steel grit. In the plating department, for example, it was necessary to dip work in acid to remove from its surface silica imbedded in the metal; if this was not done, a poor finish was obtained, since silica is not an electrical conductor. With steel grit such a condition is not possible, since steel is an electrical conductor. Likewise, in the case of work to be japanned or lacquered, the cleaner surface produced by steel grit facilitated the operation.

Then there was a great saving in the iron nozzles from which the mixture of air and sand or steel grit emerged. Where three nozzles a day were used with the sand, one nozzle lasted from three to four weeks with the steel grit. In general, it was found that there was less wear on metal parts of the equipment, and less replacement was the net outcome. Considerable savings were indicated from the number of shovels, sieves, and other equipment required.

The work described was done by the Engineering Department of the P. & F. Corbin Division of the American Hardware Corporation. (Walter J. Sorrow, Works Mgr. of P. & F. Corbin. New Britain, Conn., in *The Iron Age*, vol. 127, no. 5, Jan. 25, 1931, pp. 393–394, 2 figs., *p*)

STEAM ENGINEERING (See Power-Plant Engineering: German Progress Report for 1930)

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Manufacture of Insulating Board From Cornstalks

THIS publication gives detailed data about the location and quantities of cornstalks available, the physical and chemical composition of the stalks and parts thereof, and the methods and costs of harvesting and baling the stalks and delivering them to the factory. It also describes the experimental work in the manufacture of this material, together with such related subjects of research as refrigeration board, waterproofing, and fireproofing.

The general description of the process is given from which it would appear that the stalks first pass to a magnetic separator where any tramp iron present is removed; they are then shredded to proper size and delivered to beaters, where the stalks with addition of water are beaten into a pulp. The stuff with additions of alum and rosin is then pumped to the mat-forming machine, from which it goes to the press rolls of the board-forming machine. A list of equipment that will be required for commercial production is given, together with a detailed estimate of costs as well as expected uses for this material. (O. R. Sweeney and W. E. Emley in *Bureau of Standards Miscellaneous Publications*, no. 112, Oct. 18, 1930, 27 pp., 12 figs., some on separate inserts, *dp*)

Pressure Die Castings of Aluminum Bronze

A NOVEL application of die-casting practices has been developed by the Aurora Metal Co., Aurora, Ill. The company manufactures pressure die castings of aluminum bronze, which are cast at temperatures of about 2300 deg. fahr.

On account of the uniform accuracy to which it is claimed these castings are made, they require a minimum of machining, and in many cases no machining at all. The tensile strength of this material as cast is 85,000 lb. per sq. in. It has a hardness of Rockwell 66 B, Brinell 140. When quenched from 1700 deg. fahr., the tensile strength is 100,000 lb. per sq. in., and the hardness 110 Rockwell B, 260 Brinell. Any desired hardness between these limits can be obtained by proper heat treatment.

These die castings also have a high tensile strength at elevated temperatures. Die-cast test bars showed the following results at temperatures indicated below:

Temperature, deg. fahr.	Tensile strength, lb. per sq. in.
70	84,800
400	66,800
550	59,000
800	40,300
1000	19,000

The aluminum bronze having the above properties has the composition: 89 per cent copper, 10 per cent aluminum, and 1 per cent iron, By making slight variations in the composition of the alloy, changes can be effected in the physical properties of the die castings to suit particular requirements.

The corrosion resistance, absence of aging changes, resistance to shock, and great tensile strength claimed for aluminum bronze, should make its use advisable where any of these qualities would be advantageous. (*The Iron Age*, vol. 127, no. 5, Jan. 29, 1931, p. 405, *d*)

Steel Grit for Sand Blasting

THE article here abstracted reports tests on blasting made with alundum silica sand and commercial steel grit. Two hundred pounds of each material were used, and the number of pieces of work blasted before the 200 lb. were exhausted was noted. It was found that the silica sand broke down at 4700 pieces and the alundum at 20,000, while steel grit ran in excess of 80,000 pieces. On the other hand, sand costs $6 a ton, including freight charges, and steel grit, $100. Practically no dust was visible in the cabinets with steel grit.

There are several other advantages of steel grit. Thus, with sand it was necessary to clean the screen separator on the exhaust system twice a week, whereas with steel once in three months suffices. The saving in labor from handling 16 tons of steel grit a year against 330 tons of silica sand is also appreciable.

There were also other advantages derived from the use of steel grit. In the plating department, for example, it was necessary to dip work in acid to remove from its surface silica imbedded in the metal; if this was not done, a poor finish was obtained, since silica is not an electrical conductor. With steel grit such a condition is not possible, since steel is an electrical conductor. Likewise, in the case of work to be japanned or lacquered, the cleaner surface produced by steel grit facilitated the operation.

Then there was a great saving in the iron nozzles from which the mixture of air and sand or steel grit emerged. Where three nozzles a day were used with the sand, one nozzle lasted from three to four weeks with the steel grit. In general, it was found that there was less wear on metal parts of the equipment, and less replacement was the net outcome. Considerable savings were indicated from the number of shovels, sieves, and other equipment required.

The work described was done by the Engineering Department of the P. & F. Corbin Division of the American Hardware Corporation. (Walter J. Sorrow, Works Mgr. of P. & F. Corbin. New Britain, Conn., in *The Iron Age*, vol. 127, no. 5, Jan. 25. 1931, pp. 393–394, 2 figs., *p*)

STEAM ENGINEERING (See Power-Plant Engineering: German Progress Report for 1930)

TESTING AND MEASUREMENT

A Direct Method for Obtaining Stress-Strain Diagrams of Notched-Bar Impact Tests

THE author has succeeded in devising a very simple apparatus for taking photographs of stress-strain diagrams of impact tests directly. The mode of vibration of the test piece is then studied on the photograms. The diagram is taken directly without the aid of integration or differentiation, and it appears that there is a close agreement between the absorbed energy measured from the difference of heights of the hammer before and after the impact and that measured from the area of the diagram.

In impact testing with the Izod-type tester, the part near the notch will be deformed permanently. But the lower portion of the test piece near the cramp will be deformed only elastically if the notch is sufficiently deep, and after the impact the deformation will recover, the test piece returning to its initial position.

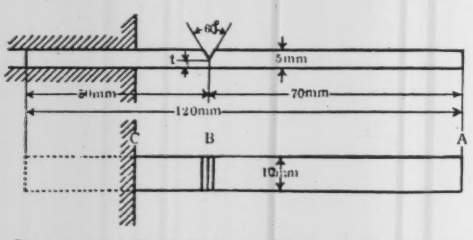

FIG. 5 DIAGRAM OF TEST PIECE IN NOTCHED-BAR IMPACT TEST

This slight elastic deformation is unavoidable in every type of notched-bar impact test. The author took advantage of this small elastic deformation for the measurement of stress of the test piece during impact. Now, as the deformation is small, the elastic deformation near the cramp of the test piece may be considered to be proportional to the stress exerted by the impact. (This proportional relation is ascertained by preliminary experiment.) Thus, if a small mirror is fixed at this portion, it is possible to determine the magnitude of the stress by measuring optically the deflection of the mirror during impact. Next, the amount of deformation of the test piece at the notch during the process of destruction may be measured by the displacement of the hammer from its initial position, when the first contact with the test piece takes place, as in the case of Körber and Storp's method.

The light beam is reflected by the small mirror which is fixed to the lower part of the test piece; then by means of two further reflections by two mirrors it is directed on to a dry plate which is fixed to the hammer parallel to its plane of oscillation. When the mirror attached to the test piece is deflected by the impact force of the pendulum hammer, the light spot on the dry plate moves vertically while the hammer with the dry plate moves horizontally. In this way the stress-strain diagram may be taken. Another beam produces a spot on the dry plate, and this serves as the base line of the stress-strain diagram, assuming that the positions of these two spots are adjusted so as to coincide before the hammer strikes the test piece. The method of calculation is presented in detail in the original article, and reproductions of stress-strain diagrams are also given. Among other things, it has been noted that small vibrations occur in the range just previous to the yield point where one should have an elastic range in a static test. After the yield point a somewhat irregular damped oscillation occurs. At the point D where the hammer leaves the test piece (in the impact test the test pieces were not broken apart but merely deformed plastically), the diagram rapidly returns to zero and then superposition of two regulated oscillations follows, one of which is larger in amplitude and longer in period than the others.

The experimental facts enumerated above may be explained as follows: The test piece may be regarded as a cantilever BC with a load AB, elastically connected through a thinner part B (see Fig. 5). When, therefore, the test piece receives a shock by any cause whatever it will be subjected mainly to two modes of vibration: one is the vibration of the part BC, caused by the elasticity of the notch B, and the other, the secondary vibration due to the part BC, as a cantilever with a load fixed at its free end B. These two modes of vibration can be clearly observed on the right hand side of the point D, i.e., in the range where the test piece has detached itself from the hammer and makes its self-oscillation by the energy stored at E.

During impact the secondary vibrations due to the vibration BC, Fig. 5, give rise to the vibrating change of the stress. (Tomakazu Asano in *Memoirs of Ryojun College of Engineering*, vol. 3, no. 2-D, 1930, pp. 137–144 and 2 plates, *e*)

Vertical Propeller-Type Pumps

TWO pumps of this type deliver circulating water to the condenser at the James H. Reed Station of the Duquesne Light Company on Brunots Island, near Pittsburgh. A cross-section of the pump is shown in Fig. 6. The water is guided into propeller P through the nozzle formed by the tunnel guide cone C and the bell-shaped end of the pump. After leaving the propeller the water passes through guide vanes G and thence into the body of the pump, which takes the form of a diffuser, wherein the velocity is reduced and converted into pressure in an efficient manner. A splitter S is installed in the discharge elbow to reduce the losses at that point.

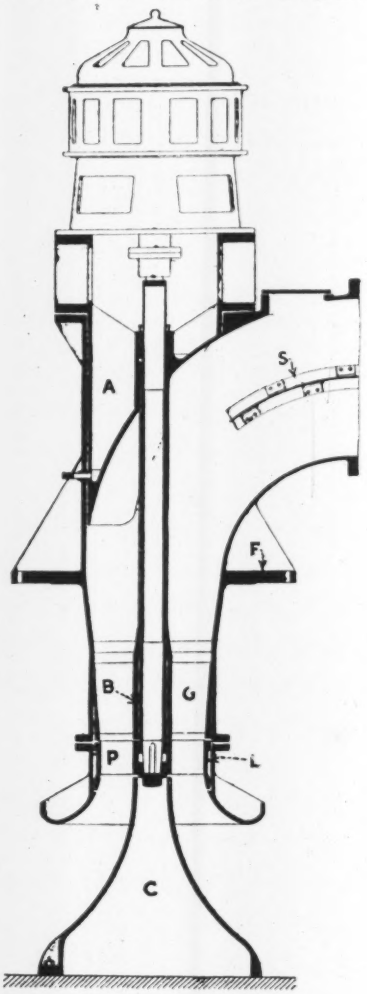

FIG. 6 SECTION THROUGH VERTICAL PROPELLER-TYPE CONDENSER CIRCULATING-WATER PUMP

The propeller rotates in a renewable liner L of bronze or other suitable material. A water-lubricated Goodrich rubber bearing B in the center of the guide-vane casting takes the radial load. Liberal clearance is allowed between the propeller and liner, since the efficiency of the pump is not affected appreciably by the amount of clearance at this point. The pump is mounted on its feet F, which carry the combined weight of the pump and motor. Only one gland is necessary, contained in the pump plug A and under pressure.

An illustration in the original article shows the guide vanes

with the rubber bearing in place. The bearing has spiral grooves which permit circulation of water for lubrication. One of these pumps was given a complete capacity test before shipment from the factory, and the curves of the test are given in the original article. The maximum efficiency was of the order of 87 per cent on the dynamometer reading.

The tunnel guide cone (*C*, Fig. 6) is only necessary in cases where the tunnel dimensions are limited. If the tunnel section is sufficiently large and deep, the bell-shaped inlet to the pump will impart the necessary streamline flow to the entering water.

When desirable the pump may be installed vertically in a horizontal pipe line, and a gate valve may be placed adjacent to the propeller without impairing the efficiency. This permits the use of the smallest possible valve.

The high efficiency obtained with this pump can be attributed to three fundamental features: (1) the propeller has only two cutting edges; (2) the propeller surface in contact with the water, and causing friction, is a minimum for the volume handled; and (3) the design of the pump is such that it reduces to a minimum the losses resulting from changing the velocity and direction of flow of the water within the pump. It is interesting to note that the tip diameter of the propeller for the pumps is only 30⅞ in. One-third of this diameter is taken up by the hub.

This type of pump is said to be inherently suited to the handling of large volumes against low heads. There is no minimum limit to the head for which it can be applied and produce maximum efficiency. The only factor that limits the maximum head at best efficiency is the velocity through the propeller. This velocity must be kept within the limit that can be obtained safely with the available absolute pressure at the propeller inlet. Thus it is evident that if the pump can be submerged under a positive head of fluid a higher velocity through the propeller is possible and a correspondingly higher head can be obtained at the point of best efficiency.

Numerous experiments are said to have proved that the value of the maximum efficiency obtained is not affected by the head and capacity conditions for which the pump may have been designed, so long as the velocity through the propeller does not approach too closely the maximum velocity theoretically obtainable. (J. W. McNulty, Engineering Department, Westinghouse Elec. & Mfg. Co., in *Power*, vol. 73, no. 2, Jan. 13, 1931, pp. 62–63, 5 figs., *d*)

THERMODYNAMICS (See Engineering Materials: Stresses in Boiler and Superheater Tubes; Power-Plant Engineering: German Progress Report for 1930)

WELDING

Experiments on Gas-Welded Structural Joints

AMONG other things, the author considers the question as to how much the strength of a gas weld depends upon the skill and experience of the operator. On the one hand, specimens were prepared by college students, and on the other, by commercial organizations. The results are given in a table and would indicate that amateurs can produce excellent welds. The next question was how welded joints compare with riveted joints.

When connecting a single leg of an angle to a gusset plate with rivets, flexural stresses are set up upon application of a load. The flexural stresses are due to the eccentricity of the connection. The author can best demonstrate the effect of an eccentric load by the use of a steel band, or spline. The spline was connected at each end to wooden blocks. Pins were inserted off center from the spline by a distance e. Now, if a pull is exerted by way of the pins, a bending moment is induced, by the eccentricity e and the load, equivalent in magnitude to $M = Pe$. The bending moment sets up flexural stresses of tension and compression, indicated by the bent spline. It will be noted that the central portion of the spline seeks to attain the line of the pull: Nature tries to remove the eccentricity.

When the leg of an angle is riveted to a gusset plate, the connection does not coincide with the center of gravity of the angle: the connection is eccentric. As a load is applied, flexural stresses are set up in both legs. Some authorities have recognized this fact and reduced the allowable load. But just how serious is it? The author is afraid most designers have made just a guess. Some authorities consider the use of a lug angle as removing this objectionable eccentricity. Others claim it is of no value.

If this condition exists in riveted connections, is it to be found in welded connections? Theoretically, the eccentricity could be avoided in one leg by the proper distribution of the weld, but did it actually do this? Would the use of a lug angle remove the eccentricity in the outstanding leg? The author could find no answers. Previous tests had been on short-length members. Experimenters had been more interested in the strength of the weld than in the stresses set up in the member itself.

In order to allow for the longest possible length of angle which the testing machine would take, the tests were practically limited to the use of a $2\frac{1}{2} \times 2\frac{1}{2} \times \frac{3}{8}$-in. angle. The connection was made at each end by means of two bars so as to eliminate all possibility of torsional stresses from the testing machine.

It might be well to mention how the unit stress was determined at the various locations. As a load is applied to a steel member, up to a certain point called the yield point, unit deformation is proportional to unit stress. This ratio, called the modulus of elasticity, can be accurately determined. If the ratio is known, and the unit deformation (stretch) is determined, the unit stress can be computed. The Berry strain gage was used to determine the unit deformation. The author shows a photograph of the strain gage being applied to one of the test members.

Readings were taken over the entire angle and connection. As was expected, the intensity of stress increased from the connection to the gage-station line halfway between connections.

The results would seem to indicate that, for the working load, the stress distribution of the welded joint is little, if any, better than for the riveted joint. Of course it must be remembered that the unit stress at the minimum section of the riveted connection has not been shown. And this section is the weak point.

The welded connection seems to indicate more eccentricity in the plane of the connected leg than the riveted member. The author has been questioning the present method of figuring the weld distribution for the angle connection. He is not so sure it cannot be improved. But this demands research, and so far funds with which to try it have not been available.

When tested to final destruction, the gas-welded specimens, as was to be expected, made a much better showing than the riveted ones. (James R. Griffith, Professor of Structural Engineering, Oregon State Agricultural College, in a paper read before the 31st Annual Convention of the International Acetylene Association, Nov. 12–14, 1930; abstracted from mimeographed copy, *ecp*)

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

Engineering and Industrial Standardization

U. S. Government Printing Office Joins A.S.A.

THE affiliation of the United States Government Printing Office, Washington, D. C., the largest printing plant in the world, with the American Standards Association, was announced early last month. It is the eighth division of the Federal Government to become a member of the association.

George H. Carter, the public printer, has appointed B. L. Wehmhoff, technical director in charge of the Research Laboratory of the Office, as its representative on the A.S.A. Standards Council, the body which governs the technical work of the association.

Standardization of blank forms and stationery of various types has been effected by the Printing Office, resulting in the elimination of waste and confusion. Standard specifications are now established for the purchases of such materials as paper, ink, and type-metal alloys. The Research Laboratory carries on constant investigations covering paper, type metal, inks, adhesives, and numerous other printing and binding materials. It also studies air-conditioning and other engineering problems of a printing plant. Extensive tests of newsprint paper have been made in cooperation with the Mechanical Department of the American Newspaper Publishers' Association.

Light-Metals Group Joins A.S.A.

THE formation of a Light-Metals Group, with the Aluminum Company of America as the first member of the group, is announced by the American Standards Association. This group becomes the forty-fifth member-body of the association with representation on the A.S.A. Standards Council. The Standards Council now includes organizations of national scope representing a large proportion of the major branches of the manufacturing, mining, and public-utility industries, national engineering societies, safety and insurance groups, and several departments of the Federal Government. Other industrial groups represented on the A.S.A. Standards Council in addition to individual national trade and technical organizations are the Electric Light and Power Group, the Fire-Protection Group, the Small-Tools Group, and the Telephone Group, each consisting of a number of trade associations, or industrial units of comparable scope and magnitude, and allied interests. It is expected that the creation of the Light-Metals Group will greatly stimulate the establishment of national standards and specifications covering the processes and products of the light-metals industry, which include aluminum and magnesium, their alloys, and alloys of these metals with other metals.

Specifications for Leather Belting

AT THE Annual Meeting of the American Standards Association a resolution was passed requesting The American Society of Mechanical Engineers to accept sole sponsorship for the development of standard specifications for leather belting. This resolution was in line with the recommendations which had been received from a conference committee formed at the time of the general conference held in New York on February 6, 1930, the members of which were Messrs. J. C. Mattern, Wm. Staniar, and C. O. Streeter.

The report of this conference committee recommends that the project should be limited for the present to standard specifications for vegetable-tanned leather belting, and to cover raw material, method of manufacture and construction, marking, and physical and chemical tests.

The conference committee justified its recommendation on the statement made at the conference that the consumption of this kind of belting in the United States was estimated to be 85 per cent of the total belting manufactured, the remaining 15 per cent being constructed of combination-tanned and chrome-tanned leather. It was understood that the development of specifications for other tanning processes would be undertaken as soon as demanded by the industry.

The American Society of Mechanical Engineers has accordingly issued invitations to all societies and trade associations known to be interested in the manufacture and use of this product, inviting them to appoint official representatives on the sectional committee which will be organized to develop the standard.

Foundry Equipment Project Approved

THE American Standards Association at a recent meeting accepted a report of its special committee which recommended initiation of a new standardization project dealing with foundry equipment. This special committee, headed by G. L. Markland as chairman, consisted of

R. L. Collier, Steel Founders' Society of America
R. P. Dryer, Executive Sec'y, Foundry Equipment Manufacturers Association
Dr. Z. Jeffries, Aluminum Company of America
R. E. Kennedy, Tech. Sec'y, Am. Foundrymen's Assn.
C. B. LePage, Asst. Secretary A.S.M.E.
G. L. Markland, Member A.S.A. Standards Council
P. J. Potter, Foundry Equipment Manufacturers Assn.
Wm. G. Schneider, Copper and Brass Research Assn.

The report included a recommendation that the American Foundrymen's Association and The American Society of Mechanical Engineers be invited to accept joint sponsorship for this project and to organize a sectional committee to develop the group of American Standards.

The special committee did not reach an agreement on the wording of the scope of the project, but suggested tentatively the following wording and recommended that the sponsor organizations and the Sectional Committee be requested to consider this subject of scope and modify the proposed wording where considered necessary:

> Standardization of such foundry equipment as pattern plates and molding-machine parts affecting interchangeability of patterns flask pins and holes, general dimensions of flasks for jobbing work, ladle and ladle-shank sizes, ladle sleeves, stoppers and nozzles, stock core-print sizes, shapes and finish allowances, pattern markings, rapping plates, fillet sizes, and dowel pins for metal patterns and metal core boxes.

This project will be known in the files of the American Standards Association as B 45.

Several years ago the various branches of the foundry industry cooperated with safety organizations and other bodies under the procedure of the American Standards Association in the preparation of a national safety code for the protection of foundry workers against injury through accidents.

Abbreviations of Scientific and Engineering Terms

Proposed American Tentative Standard

UNDER the procedure of the American Standards Association, a subcommittee[1] of the Sectional Committee on Scientific and Engineering Symbols and Abbreviations has prepared an American Tentative Standard on Abbreviations for Scientific and Engineering Terms. This report is now being submitted to the sponsor bodies[2] for approval.

A study of the report, copies of which may be procured by addressing C. B. LePage, The American Society of Mechanical Engineers, 29 West 39th Street, New York, N. Y., indicates that the committee avoided including on the one hand abbreviations likely to be used to a greater extent in general literature than in scientific and engineering literature, and, on the other hand, extensive lists of highly technical abbreviations used only by specialists. Also it will be noted that the abbreviations listed are for use in text matter in books and magazines. Many abbreviations that might be appropriate for drawings, name plates, and bills of material were not considered. Simplification, such as the omission of periods, has been arrived at with a view to economy in composing rooms and with understanding of the limitations of typesetting and linotype machines by means of which most printed material is set.

The report consists of two parts, "Fundamental Rules for Formation and Use," quoted below, and the abbreviations themselves, a few samples of which are also given.

Fundamental Rules for Formation and Use

Abbreviations should be used sparingly in text, and with regard to the context and to the training of the reader. Terms denoting units of measure should be abbreviated in the text only when preceded by the amounts indicated in numerals; thus "several inches," "one inch," "12 in." In tabular matter, specifications, maps, drawings, and texts for special purposes, the use of abbreviations should be governed only by the desirability of conserving space.

A sentence should not begin with a numeral followed by an abbreviation.

Capitals in abbreviations should be avoided unless the words abbreviated are normally capitalized.

Hyphenated compound words usually call for hyphenated abbreviations; thus "ft-lb" (for the sake of closer agreement with the recommendations of the International Electrotechnical Commission; exception to this rule is made in the cases of abbreviations for the names of certain electrical units, as va for volt-ampere).

With but few exceptions of abbreviations in common usage, the singular only should be used; thus "in." for "inches," not "ins."

Short words such as ton, day, and mile should be spelled out.

Abbreviations should not be used where the meaning will not be clear. In case of doubt, spell out.

The use of conventional signs for abbreviations in text is not recommended; thus "per," not / ; "lb," not "#" ; in., not ″ . Such signs may be used sparingly in tables and similar places for conserving space.

The Committee endorses the movement which was begun by the International Committee on Weights and Measures in omitting the period in abbreviations of metric units, and further endorses the growing tendency toward the omission in abbreviations of other origin. In the interests of economy and the reduction of waste the Committee recommends the elimination of the period except where such an omission results in an English word. Exceptions to this practice will be found in a few mathematical and chemical terms, such as sin, tan, log As, etc.

The letters of such abbreviations as A.S.M.E. should not be spaced (not A. S. M. E.).

The use in text of exponents for the abbreviations of square and cube and of the negative exponents for terms involving per is not recommended. The superior figures are usually not available on the keyboards of typesetting and linotype machines, and composition is therefore delayed. There is also the likelihood of confusion with footnote reference numbers. These shorter forms are permissible in tables, and are sometimes difficult to avoid in text.

Typical Abbreviations

Ampere	a or A*
Brake horsepower	bhp
Cubic foot	cu ft
Degree fahrenheit	F
Electromotive force	emf
Feet per second	fps
Hour	h or hr
Indicated horsepower	ihp
Kilowatt-hour	kwh or kWh*
Meter	m
Pound	lb
Revolutions per minute	rpm
Square foot	sq ft
Tensile strength	ts
Volt-ampere	va or Va*

NEW AMERICAN STANDARDS

The following standards were approved by the A.S.A. during the month of January 15–February 15, 1931:

Zinc Coatings on Structural-Steel Shapes, Plates, and Bars and Their Products, (G 8c). (American Tentative Standard.)

Sponsored by the American Society for Testing Materials. Published by the American Society for Testing Materials.

General Methods of Testing Woven Textile Fabrics, (L 5). (American Standard.)

Proprietary Sponsor—The American Society for Testing Materials. Published by the American Society for Testing Materials.

[1] The initiating subcommittee consists of George F. Bateman, professor of mechanical engineering, Cooper Union, New York, N. Y., S. McKay Gray, Electrical Testing Laboratories, New York, N. Y., William T. Magruder, professor of mechanical engineering, The Ohio State University, Columbus, Ohio, and George A. Stetson, Chairman, Editor, The American Society of Mechanical Engineers, New York, N. Y.

[2] The sponsor bodies are the American Association for the Advancement of Science, the American Institute of Electrical Engineers, the American Society of Civil Engineers, the Society for the Promotion of Engineering Education, and The American Society of Mechanical Engineers.

* Abbreviation recommended by International Electrotechnical Commission.

Proposed Specifications for Fusion Welding

Based on Proposed Specifications for Fusion Welding of Unfired Pressure Vessels Published in the December, 1930, Issue of "Mechanical Engineering," and Proposed Specifications for Fusion Welding of Drums or Shells of Power Boilers, Published in the March and December, 1930, Issues of "Mechanical Engineering"

THE following proposed revisions, which are now under the joint consideration of the American Welding Society and the Boiler Code Committee, are for embodiment in the Code for Unfired Pressure Vessels and for embodiment in the Code for Power Boilers.

The Boiler Code Committee invites communications from those who approve the specifications, as well as from those who wish to suggest changes. Communications should reach the Secretary of the Boiler Code Committee, 29 West 39th St., New York, N. Y., not later than April 6, 1931, in order that they may be presented to the Committee for consideration.

PROPOSED REVISIONS AND ADDITIONS TO CODE FOR UNFIRED PRESSURE VESSELS FOR FUSION-WELDED CONSTRUCTION

Pressure vessels may be fabricated by means of fusion welding provided the construction is in accordance with the requirements for material and design as required by this Code and the fusion welding process used conforms to the specifications for the grade of welding indicated for each class of vessel.

Fusion-welded pressure vessels shall be classified according to the following schedule. The grade of welding required for each class shall be as indicated.

Class 1. All vessels covered by this Code, constructed in accordance with the rules for this class, may be used for any purpose. This class includes vessels containing noxious, poisonous, or inflammable liquids or gases. These vessels shall be welded with Grade A welding. The allowable working stress shall be 18 per cent ($^1/_5$ of 90 per cent) of the minimum of the specified tensile range of the plate used.

Class 2. All vessels covered by this Code are included in this class, excepting those containing noxious or poisonous gases or liquids, provided the plate thickness does not exceed $1^1/_4$ in. These vessels may be welded with either Grade B or Grade C welding. When Grade B welding is used, the allowable stress shall be 16 per cent ($^1/_5$ of 80 per cent) of the minimum of the specified tensile range of the plate used. When Grade C welding is used, the allowable stress shall be 14 per cent ($^1/_5$ of 70 per cent) of the minimum of the specified tensile range of the plate used.

Class 3. All vessels covered by this Code not exceeding $^3/_8$ in. plate thickness and used for the storage of gases or liquids at temperatures not exceeding their boiling temperature at atmospheric pressure, may be included in this class, except those containing noxious, poisonous, or inflammable liquids or gases. These vessels may be welded with Grade D welding. The allowable working stress shall be 12 per cent ($^1/_5$ of 60 per cent) of the minimum of the specified tensile range of the plate used for butt joints, and 10 per cent ($^1/_5$ of 50 per cent) for double-fillet-welded lap joints.

The allowable working stresses on the joints in pounds per square inch for different temperatures are given in Table 1.

NOTE: It does not follow that any vessel in which the plate thickness does not exceed $^3/_8$ in. necessarily falls in Class 3, since if welded with Grade A welding it would fall in Class 1, and if welded with Grade B or C welding it would fall in Class 2.

The above classification gives the general features governing the classes into which the various vessels will be placed. The Boiler Code Committee will prepare a list indicating the classes into which the vessels for various uses shall be grouped. It is proposed to stamp each vessel to designate its class and the grade of welding used.

Plate Material. The materials used in the fabrication of any fusion-welded pressure vessel covered by this Code shall conform to Specifications S-1 for Steel Boiler Plate and S-2 for Steel Plates of Flange Quality for Forge Welding, of Section II (1930 Edition) of the Code.

Longitudinal Joints. Longitudinal joints on Class 1 and Class 2 vessels shall be of the butt type and shall be reinforced at the center of the weld on each side of the plate in accordance with Par. U-71. This reinforcement may be machined off, if so desired. The longitudinal joints of Class 3 vessels may be of the butt or lap type. If of the lap type the throat dimension of the weld shall not be less than $1^1/_4\ T$, where T represents the thickness of the plate. Both edges of the lap shall be welded and the overlap of the plate shall not be less than $4T$.

Circular Joints. Circular joints on Class 1 and Class 2 vessels shall be of the butt type and shall conform to the requirements for longitudinal joints. Circular joints on Class 3 vessels may be of the butt or lap type, either of which shall conform to the requirements for longitudinal joints.

Dished Heads. Dished heads concave to the pressure when used on Class 3 vessels may be inserted in shells with a driving fit and fillet welded inside and outside, except that on vessels 20 in. in diameter or less the heads may be welded on the outside only.

Qualified Welders. All welding on vessels covered by this Code shall be done by "qualified welders." A "qualified welder" is one who has demonstrated his ability to produce welds which will meet the required tests for the grade of welding for which he is to qualify.

Each qualified welder shall be assigned by the manufacturer an identifying number, letter, or symbol which shall be stamped on all vessels adjacent to and at intervals of not more than 3 ft. along the welds which he makes either by hand or by machine.

The manufacturer shall maintain a record of the qualified welders in his employ, showing the date and result of the qualification tests and the identification mark assigned to each. These records shall be accessible to the inspector at all times.

A welder's qualification shall be effective for a period of 6 months only, at the end of which time a repetition of the qualification tests shall be made.

Stress Relieving. All Class 1 fusion-welded vessels shall be stress relieved. Class 2 fusion-welded vessels shall be stress relieved in accordance with the following:

Longitudinal welds shall be stress relieved where the wall thickness is greater than 0.55 in. and the shell diameter less than 20 in.

Transverse or girth welds shall be stress relieved where the wall thickness is greater than 0.7 in. and the shell diameter less than 40 in.

For other wall thicknesses and shell diameters, stress relieving shall be required for all welds where the ratio of the diameter to the cube of the shell thickness is less than 118.

Where stress relieving is required, it shall be done in accordance with the rules given in Par. 4 of the Proposed Specifications for Fusion Welding of Unfired Pressure Vessels published in the December, 1930, issue of MECHANICAL ENGINEERING.

Holes. No unreinforced holes shall be located in a welded joint. When an unreinforced hole in the plate is located near a welded joint, the minimum distance between the edge of a hole and the edge of a joint shall be equal to the thickness of the plate when the plate thickness is from 1 in. to 2 in. With plates less than 1 in. thick, this minimum distance shall be 1 in. With plates over 2 in. in thickness, the minimum distance shall be 2 in.

Inspection. An inspector may designate stages of the work at which he wishes to inspect the welded joints of a Class 1 vessel, and the manufacturer shall either submit the drum for inspection in such partly completed condition, or as an alternative he may permit the inspector to witness stages of the welding operation at such times as the inspector may select.

NOTE: The X-ray examination required for the joints for Class 1 vessels provides a greater safeguard than any shop inspection.

Class 2 pressure vessels shall be inspected at least twice, and every Class 3 pressure vessel shall be inspected at least once, during construction.

For Class 2 vessels the first inspection shall be made during the welding of the longitudinal joint. At this time the inspector shall inspect the plate material and the fit-up of the work, and observe the workmen to see that only qualified welders are employed on the work of welding. A second inspection shall be made during the welding of the circumferential joints. At this time the inspector shall check any new material being used which may not have been examined at the time of the first inspection, also the fit-up of the vessel at this stage of construction, and again observe the welding operators to see that only qualified welders are employed on the work of welding.

For Class 3 vessels one inspection shall be made during the welding of the longitudinal joint. At this time the inspector shall check the plate material and the fit-up of the work, and observe the workmen to see that only qualified welders are employed on the welding work.

Every pressure vessel covered by this Code shall be inspected while under the hydrostatic-pressure test.

The manufacturer shall certify that only qualified welders, as designated by their qualification symbols, have been employed on the work of welding.

Hydrostatic and Hammer Tests. All fusion-welded pressure vessels which are not stress relieved shall be subjected to a hydrostatic pressure of sufficient intensity to stress the longitudinal welded joints to $1^1/_2$ times the maximum allowable working stress for the grade of welding used in the tank in question, and while subject to this hydrostatic pressure a thorough hammer test shall be applied. This test shall consist of striking the sheet on both sides of the welded joint a sharp blow with a long-handled hammer which shall be 10 per cent of the weight of 1 sq. ft. of the wall of the vessel and not less than 2 lb. The blows shall be struck 2 to 3 in. apart along the joints, as rapidly as a man can conveniently strike a sharp, swinging blow, and as hard as can be struck without indenting the metal of the sheet. After the hammer test, the pressure shall be raised to a point which will stress the longitudinal joint to $2^1/_4$ times the maximum allowable working stress, and held at this pressure for three minutes.

All vessels which have been stress relieved shall be subjected to a hydrostatic pressure of sufficient intensity to stress the longitudinal joints to $2^1/_4$ times the maximum allowable working stress, and held at this pressure for three minutes.

SPECIFICATIONS FOR THE VARIOUS GRADES OF WELDING

Grade A Welding. The specifications for Grade A welding shall be the Proposed Specifications for Fusion Welding of Unfired Pressure Vessels as published in the December, 1930, issue of MECHANICAL ENGINEERING, with the exception that Par. 8, Impact Tests, is to be omitted and Pars. 12, Hydrostatic and Hammer Tests, 13, Holes, and 14, Allowable Working Stress, are to be revised as herein set forth.

Grade B Welding. The requirements for Grade B welding are the same as for Grade A, except that no X-ray tests are required for the joints of the completed vessels, stress relieving is not required in all cases, and the ductility requirement by the free-bend-test method is reduced from 30 to 20 per cent.

Prior to, but not exceeding six months, before beginning the construction of vessels with Grade B welding as covered by this Code, the manufacturer shall have tested samples of welding of the thickness of plate used in the vessels which he is to build in order to qualify the process which he employs. The requirements for these qualification tests shall include an X-ray examination of the welds, as well as the other tests designated for Grade A welding.

Grade C Welding. This applies to welding that must of necessity be done in other than a horizontal position. The requirements are as given for Grade B welding, except that the samples shall be welded in the position encountered in the manufacture of the vessel and the required ductility by the free-bend-test method is reduced from 20 to 12 per cent.

TABLE 1 ALLOWABLE STRESSES AT DIFFERENT TEMPERATURES FOR THE THREE CLASSES OF VESSELS AND FOR THE FOUR GRADES OF WELDING FOR STEEL SHELL PLATES COVERED BY THE SPECIFICATIONS

Class	Grade of welding	Longitudinal joint efficiency, per cent	Minimum tensile strength, lb. per sq. in.	Temperature, Degrees Fahrenheit 60	650	700	750	800	850	900	950
1	A	90	55,000	9900	9900	9900	9000	7200	6100	4950	3600
			50,000	9000	9000	9000	8200	6600	5450	4350	3250
			45,000	8100	8100	8100	7400	5900	4900	3900	2900
2	B	80	55,000	8800	8800	8800	8000	6400	5400	4400	3200
			50,000	8000	8000	8000	7300	5800	4850	3850	2900
			45,000	7200	7200	7200	6550	5250	4350	3450	2550
	C	70	55,000	7700	7700	7700	7000	5600	4750	3850	2800
			50,000	7000	7000	7000	6350	5100	4250	3400	2500
			45,000	6300	6300	6300	5700	4550	3800	3000	2300
3	D Butt-welded joints	60	55,000	6600[a]	..	..	..	..	..	..	..
			50,000	6000[a]	..	..	..	..	..	..	..
			45,000	5400[a]	..	..	..	..	..	..	..
	D Lap-welded joints	50	55,000	5500[a]	..	..	..	..	..	..	..
			50,000	5000[a]	..	..	..	..	..	..	..
			45,000	4500[a]	..	..	..	..	..	..	..

[a] These values may be employed for all conditions for which Class 3 vessels may be used.

Grade D Welding. Prior to the construction of any vessels covered by this Code requiring Grade D welding, the manufacturer shall have tested samples of welding of plates approximately $^1/_4$ in. and $^3/_8$ in. thick in order to qualify the process which he employs. The test specimens shall be the same as for Grade A welding and shall meet the following requirements:

Tensile Test: The ultimate tensile strength shall not be less than the minimum of the range stamped on the plate.

Ductility Test: The percentage of ductility as shown by the free bend test shall not be less than 10 per cent.

PROPOSED SPECIFICATIONS FOR FUSION WELDING OF DRUMS OR SHELLS OF POWER BOILERS

It is proposed to make the Proposed Specifications for Fusion Welding of Drums or Shells of Power Boilers, as published in the March, 1930, issue of MECHANICAL ENGINEERING (page 235), conform with those published in the December, 1930, issue of MECHANICAL ENGINEERING under the heading of "Proposed Specifications for Fusion Welding of Unfired Pressure Vessels," except in the following particulars:

Par. 8—Impact Tests. Omit.

Par. 12—Hydrostatic and Hammer Tests. Change to read as follows:

> *Hydrostatic Test.* The vessel shall be subjected to a hydrostatic pressure of sufficient intensity to stress the longitudinal joints to $2^1/_4$ times the maximum allowable stress, and held at this pressure for three minutes.

Par. 13—Holes. Change to read as follows:

> *Holes.* No unreinforced holes shall be located in a welded joint. When an unreinforced hole in the plate is located near a welded joint, the minimum distance between the edge of a hole and the edge of a joint shall be equal to the thickness of the plate when the plate thickness is from 1 to 2 in. With plates less than 1 in. thick, this minimum distance shall be 1 in. With plates over 2 in. in thickness, the minimum distance shall be 2 in.

Par. 16. Add a new paragraph to read as follows:

> *Inspection.* An inspector may designate stages of the work at which he wishes to inspect the welded joints of a vessel, and the manufacturer shall either submit the drum for inspection in such partly completed condition, or as an alternative he may permit the inspector to witness stages of the welding operation at such times as the inspector may select.

NOTE: The X-ray examination provides a greater safeguard than any shop inspection.

Correspondence

Low-Cost Peak-Load Capacity With Bleeder Turbines

TO THE EDITOR:

The paper presented by Prof. A. G. Christie and Mr. W. Viessman at the Metropolitan Section meeting on January 8[1] proposes a very interesting method of increasing plant capacity, and is unique in that no radical change in turbine design is necessary as contrasted with the type of turbine required for conventional accumulator operation. The scheme may be commercially attractive for certain installations where load growth is relatively slow and the demand may be anticipated with a fair degree of certainty, but its value for general application seems limited.

From the standpoint of cost it is not altogether consistent to compare the increased-capacity unit costs with unit costs for a complete plant, since in effect the proposed system merely replaces a portion of boiler capacity required for meeting short peaks. Primary boiler capacity may be purchased for about $30 per kw., including building, auxiliaries, and piping, so the unit cost of the proposed scheme for any preliminary study should be compared with this figure, corrected perhaps for differences in cycle efficiencies. Under conditions most favorable to the proposed system the highest boiler-cost figure which might result when compensated for differences in cycle efficiencies would be about $35 per kw. When compared with the cost of the heat-storage system estimated at $24.36 per kw. in the paper, the possible capital savings do not seem especially attractive when the reliability of an estimate is given careful weight.

The balance between boiler capacity and turbine capacity of many plants today is out of proportion. Some are over-boilered and some under-boilered, and it should not be assumed that the under-boilered plants are incapable of carrying full load on the main turbines. Some of these under-boilered plants show a capital cost well under $90 per kw. capacity, and the boiler investment is well under $30 per kw. In a plant which is under-boilered the saving in interest on the investment is more than offset by the additional operating labor required and the outlay necessary to maintain the equipment in proper operating condition.

A perfect boiler unit would be one which would be so designed that there would be complete harmony between first cost, capacity, and operating cost for the duty it was to perform. The duty is an uncertain factor, which can be determined roughly from past experience and general trends at the time of purchase.

In case of doubt as to the future, it seems preferable to lean in the direction of economy of capital. In the design of a boiler unit the limitations to capacity must be kept clearly in mind. A narrow, high boiler is cheaper per unit of capacity than a wide, shallow boiler, but it establishes limitations on pressure drop, draft loss, and slagging tendencies almost in direct proportion to the width. A wide boiler permits the use of more superheater elements and permits a reduction pressure drop, so that this need not be a limitation. This widening of the boiler also reduces the power required by the auxiliaries, which partially compensates for the added cost of the boiler unit. Increasing capacity by this means may be accomplished at a much lower figure than that indicated in the paper, and with a great many incidental benefits not possible by the use of accumulators. It might be suggested that this type of boiler should be selected initially for the maximum capacity on the bleed cycle and then the storage system employed for the peak capacity. However, a detailed evaluation which includes all factors would probably indicate that this capacity can be provided much cheaper in the initial boiler installation. In the evaluation the fuel consumption for the load range for the life of the equipment must be balanced against investment costs, capacity, and operating charges. This, in turn, must recognize the growth of the system, probable improvements in the art, and other factors. For comparatively low load factors a proper evaluation would be favorable to a boiler having high efficiency at light load and with high peak capacity at the expense of peak efficiency and additional boiler labor for cleaning. A high load factor, on the other hand, would be favorable to a boiler having high efficiency near the maximum load condition, in which case peak load introduces little or no problem since it may be easily obtained by slight additional investment in the auxiliaries.

Rapid load growth of a system has very much the same effect as low load factor. Rapid load growth places the heat-storage system at a disadvantage since the theoretical saving cannot be measured against plant cost or even boiler costs, but only against the interest on the investment represented by the expansion of the plant earlier than might be rendered necessary by the adoption of a heat-storage system. Where the annual load growth of a large system may be anywhere between 5 and 15 per cent of the

[1] "Low-Cost Peak-Load Capacity With Bleeder Turbines," by A. G. Christie and Warren Viessman. Published in MECHANICAL ENGINEERING, February, 1931, p. 111.

previous year, addition of primary capacity to the system a year in advance is cheap insurance against the hazards of the business, to say nothing about the saving due to the higher economy made possible in the later design.

One method which might be attractive for comparatively low-load-factor plants is a simple two-stage bleed installation with boiler, superheater, and economizer, with a maximum temperature of perhaps 220 deg. entering the economizer. By shutting off or bypassing the bleed heaters the turbine capacity is increased and the boiler auxiliary capacity is likewise increased. Due to the reduction in temperature of water to the feed pump its efficiency and capacity is increased. Reduction in temperature of gas to the induced-draft fan increases its capacity greatly. The absorption of heat by the economizer is materially increased by the change in mean temperature difference and permits a much greater temperature rise without danger of steaming. This method of operation is not recommended for continuous service, but it is safe and economical for the usual peaks, with most fuels, where the necessity of running close to machine capacity is warranted.

It might be pointed out that the additional capacity from the bleeder turbine is not all clear gain since the cost is substantially higher than for a straight condensing machine. It is quite probable that some of the installations having four-stage bleeding do not earn the fixed charges on the high-pressure bleeds when all things are considered.

The suggestion of generator cooling by refrigeration to increase capacity is attractive on paper, but not in many existing machines, due to type of construction and other limitations. Many generators provided with raw-water air coolers have long enjoyed a large reduction in air temperature during winter peak-load periods due to seasonal temperature variations of about 40 deg. in the circulating water. In most large generators the field is the most difficult part of the machine to cool and is a large factor in the capacity limitation. In some existing machines insulation temperature is not the only factor, since due to the design the hottest portion of the field is not exposed to the incoming air until it has absorbed heat from some other parts of the machine. As a consequence, the hot portion does not enjoy the benefit of the reduced temperature of the incoming air. Besides additional exciter capacity would be required, and with increased field current, difficulties might be experienced with brushes and collector rings. With some designs increased temperature differences between copper, insulation, and iron result in expansion which loosens field coils and chafes insulation. There are many machines in use today which have substantial capacity margins based on temperature, and it is usually a question of company policy as to whether to adhere to contract rating or take full capacity and relieve the manufacturer of any responsibility. Many of the older machines rated at 5000 kw. are capable of carrying 8000 kw. continuously. However, this wide margin is rapidly disappearing and ultimately we may expect to obtain only what we pay for.

Any comparison with European practice is difficult of application due to differences between conditions here and abroad. In Germany the value of a man-hour in terms of coal cost is about 2 million B.t.u., while in the United States it is about 5 million B.t.u. These relations materially affect any evaluation procedure abroad, and justify much more efficient plants and other refinements to secure efficiency than we may economically justify here.

W. E. CALDWELL.[2]

New York, N. Y.

[2] Asst. to Supt. Power Plants, United Electric Light & Power Co. Mem. A.S.M.E.

TO THE EDITOR:

Referring to the paper on low-cost peak-load capacity by Messrs. Christie and Viessman, there still remains much to be done in the selection and arrangement of equipment to meet conditions of lower investment costs, standardization, simplicity, and reliability.

A glance at Fig. 1 of the paper, showing a flow chart of the scheme with four bleed points would indicate no lack of simplicity, but some question arises if the piping diagram can be made as simple as shown.

As stated, the boiler feedwater enters the boiler under full-load bleeding conditions (57,630 kw.) at 365 deg. fahr., corresponding to a saturated-steam pressure of No. 4 bleed, allowing for a terminal difference of about 178 lb.

The peak period may vary from 55,800 to 67,825 kw., entailing a change of bleed pressure of from 178 to about 125 lb. abs., while the temperature of the stored hot water will remain substantially at the assumed level of 365 deg. In order to prevent the flashing of the water when entering the boiler feed pump and vapor binding, a water column corresponding to at least 53 lb., or 122 ft., preferably much more, would have to be placed between the discharge of the hot-water accumulator and the inlet to boiler feed pump, with valve *A* at the bottom of that water leg.

The reliability of this scheme is therefore based on the assurance with which one can depend on having that water leg always filled with water and free from vapor; the operation of valves *A* and *B* must be also dependable.

The plant rate for full load of 57,630 kw., when bleeding from four points, given as 15,130 B.t.u. per kw-hr., appears rather high when compared with those attained by plants of similar size and operating under similar steam conditions. The plant rate and output of the unit, however, when operating straight condensing and feeding from storage at 365 deg., 12,900 B.t.u. per kw-hr. for an output of 67,825 kw., appears comparable with the plant rate and output when bleeding.

On the other hand, it is questionable if a debit of 14,875 — 12,900 = 1975 B.t.u. per kw-hr. for heating the feedwater, leaving the ejector condenser No. 2, to a temperature of 365 deg. is sufficient to cover the heat addition required to 1,366,000 lb. of water and the heat losses due to radiation over a period of 22 hr. It would seem that the debit should be about 1000 B.t.u. higher, bringing the plant rate during peak-load operation to 15,875 B.t.u. per kw-hr. or 4 per cent higher than with four-stage bleeding operation, which is as one would expect.

The object of the scheme is to get around the additional investment cost for a separate unit fed from a steam accumulator, and also to attain quicker readiness for service. There remains then only the question if the same object could not be attained with similar results as to cost, thermal economy, and readiness to serve by using heat storage as proposed but releasing it in form of steam rather than in form of hot feedwater.

In other words, the accumulator volume would have to be increased to allow for steam space, and the hot water flashed into steam would serve all four stages of bleeding, replacing the steam drawn from the turbine. The turbine would also operate straight condensing under the same load as with the proposed scheme and with feed heaters operating as before, but without the difficulty inherent in feeding water of more than 212 deg. fahr. into the boiler feed pump. If the lower turbine stages can pass more steam than maximum throttle opening will allow, additional power could be obtained by feeding some of the stored steam into the turbine at the third-stage bleed nozzle.

JAMES J. WAGNER.[3]

New York, N. Y.

[3] M. E. Research, Henry L. Doherty & Co. Mem. A.S.M.E.

TO THE EDITOR:

Messrs. Christie and Viessman omit discussing in their paper the fact that provision must be made for possible outage of turbine and boiler capacity. Extra equipment must be installed to protect against this contingency. The reserve capacity now required might possibly be reduced by the amount of extra capacity which could be gotten through operating the turbines non-bleed with cold feedwater. Thus only in the case of turbine outage would non-bleed operation be needed.

The gain in station efficiency claimed by the authors through use of hot-water accumulators might not be obtained in case reserve capacity were available. An extra unit might be put in service so that all would operate at about their most efficient points. If the reserve capacity were old, and relatively inefficient, however, it might be profitable to use the accumulator and shut down the old equipment except when required because of outage.

In summer time the normal high-load period usually lasts too long to make the use of an accumulator practicable. The accumulator capacity might still be valuable to protect against sudden storm peaks, allowing the shutting down of some banked boilers which would otherwise be carried for reserve.

Since the size and cost of a hot-water accumulator is proportional to the length of the peak period, an increase in the duration of the peak might make the apparatus useless. It seems that a relatively high rate of obsolescence should be provided for.

All of these factors make it necessary to analyze carefully the local conditions before a policy of depending on non-bleed operation, with or without a hot-water accumulator, can be justified. It will be interesting to watch for use of this device in the development of power plants.

BERT HOUGHTON.[4]

Brooklyn, N. Y.

TO THE EDITOR:

The reference to Sir Charles Parsons' refrigerating scheme in the paper by Messrs. Christie and Viessman suggests consideration of obtaining the same result by greater forced-convection heat transfer. Present external generator fans create only a relatively few inches of water pressure head and use 1 per cent of the output. Using pressure blowers for peak loads, doubling or even trebling the air-flow rate, appears more practical.

The plan outlined in the paper is good in that higher than rated generator loads do not require overload capacity of any boiler-plant equipment. It does, however, dictate feed-pump plans, and requires two pumps. It does appear advantageous to pump through the high-pressure heaters at boiler pressure.

There is still another variation of the plan suggested, consisting of an economizer which ordinarily lowers gases from, say, 800 to 600 deg. fahr. while heating the feedwater from 450 to 525 deg. fahr., but which could heat 70-deg. water to 225 deg. and give better air-heater performance at the higher loads when the bleeders were cut off. Induced- and forced-draft fans would be helped, and the boiler room might be able to carry the additional load, especially if storage firing were used.

M. K. DREWRY.[5]

Milwaukee, Wis.

TO THE EDITOR:

Practically all of the machines made by the writer's company have enough capacity in the steam end to carry the kva. rating of the generator at unity power factor when the normal amount of steam is being extracted. This capacity can be built into the steam end without very much additional expense; however, it does not of course increase the size of the generator or the rating of the unit, nor does it contemplate raising the most economical point above conventional practice.

The system proposed by Professor Christie and Mr. Viessman in their paper before the Metropolitan Section appears feasible, but would introduce considerable hand control during the recharging period for the accumulators. The turbines made by the writer's company can be built for a similar excess capacity without resulting in any great increase in heat consumption for the overload condition. The rating of the boilers could be increased for a two-hour peak since the feedwater would be at normal temperature.

A. C. FLORY.[6]

Milwaukee, Wis.

TO THE EDITOR:

In the discussions of the paper presented by Mr. Viessman and myself, many valuable points of view have been presented. Attention has been called to the fact that there are ways of providing valves on the turbine to increase its capacity with the bleeders in service, the assumption being that this increased capacity would meet the requirements for overload, to which attention is called in the paper. However, even if this additional capacity has been provided, it would be possible to secure still further capacity by cutting off the bleeders and allowing the steam to pass to the condenser, either with or without the use of water accumulators.

One of the discussers pointed out the possibility of boiler-feed-pump trouble. It should be borne in mind that the water reaches the boiler feed pump from the accumulator under the pressure of the fourth bleeder heater or under approximately 250 ft. head. It does not seem likely that this would result in any flashing at the pump inlet. Several discussers presented the argument that the cost of the hot-water accumulator should be compared with the cost of additional boiler plant only, as this would be all the equipment needed if the bleeders were cut out of service without providing accumulators. If additional generator capacity is to be developed, it will be quite as necessary to furnish this additional capacity in one case as in the other, so that the various estimates of boiler-plant costs submitted should be increased $5 per kw. before comparing them with the estimated costs of the accumulator. As pointed out in the presentation of the paper, the accumulator cost is probably well on the high side.

One would be led to infer from the discussion that the practice of cutting off bleeder heaters at the time of peak load, as suggested by the paper, is an untried idea. As a matter of fact it has already been put into use in several stations throughout the country. The paper simply discusses the effect of this practice upon the capacity and efficiency of the stations, and also the possibilities that are presented by the use of water accumulators in connection with the bleeders. The scheme of cutting off bleeder heaters to increase unit capacity is not a theoretical consideration as it has already been put into use. With this consideration in view, it is believed that many who have criticized this idea will later on be applying it in their own plants.

A. G. CHRISTIE.[7]

Baltimore, Md.

[4] Operating Superintendent, Brooklyn Edison Co. Mem. A.S.M.E.

[5] Assistant Chief Engineer, Power Plants, Milwaukee Electric Railway & Light Co. Jun. A.S.M.E.

[6] Manager, Steam Turbine Department, Allis-Chalmers Mfg. Co. Mem. A.S.M.E.

[7] Professor of Mechanical Engineering, Johns Hopkins University. Mem. A.S.M.E.

Crane Lubrication

TO THE EDITOR:

In looking over the specifications given by Mr. Eustis H. Thompson in his paper on "Crane Lubrication"[8] the writer notes that he has included gravity. The American Society for Testing Materials have a rule against any gravity specifications, and therefore it would be well to drop them. This is also true of Technical Paper 323-A referred to under greases on page 1061, but which has been superseded by 323-B, a later edition.

In Table 1 of the paper, color is referred to as "M.P.A." This should be "N.P.A." which refers to the National Petroleum Association's "Color." The author has also used the "Cold Test," whereas the American Society for Testing Materials has adopted the "Pour Point," which is 5 deg. higher.

The author states that one reason for using a naphthene oil such as referred to in Table 1, was the fact that they desired a low pour point. It is true that naphthene oils, such as those made from Gulf Coast crude, have a below-zero pour point, but the refining methods of today have made it possible to make a zero-pour-point oil out of Mid-Continent paraffin as well as Pennsylvania paraffin-base oils even of cylinder-stock viscosity. Therefore it would be well to mention this in order that engineers at large may be benefited by this information and not be restricted to naphthene oils for low pour point.

C. M. LARSON.[9]

New York, N. Y.

TO THE EDITOR:

During the last three years the writer's work has taken him over practically every railroad in the United States. His company is frequently called in on troubles which upon investigation very often bring out the fact that the lubrication is not introduced at the right point or in the proper manner. There have been several applications of mechanical lubricators made in which the feed has been split between two important points. This is wrong in theory, and while such applications may give good service for a time under favorable conditions, they frequently result in trouble for the equipment manufacturer, those furnishing the lubricants, and the customer. As Mr. Thompson has pointed out, there is need of closer cooperation between machinery manufacturers and the manufacturers of lubricating equipment. There is a field for some real mechanical engineering in connection with the lubricating requirements of many commercial machinery products.

C. E. SPERRY.[10]

New York, N. Y.

TO THE EDITOR:

Referring to comments made in his paper on "Crane Lubrication," the undersigned would say that, generally speaking, his company desires the lowest-priced lubricant that will do the work, but would not have at any price a lubricant which does not adequately fulfil the required conditions.

With regard to "sticky or tacky" gear lubricants being unsuitable for high tooth speeds, this does not mean that they will be thrown off the teeth, but that high internal friction may cause undesirable heating, as at times has been his experience. In such cases, a more oily medium gave better results.

It is easy to tell when grease cups become stopped up. It is impossible to turn the cap further, unless grease is expelled around the cup threads or through some other leaks.

The cold test in Table 1 shows the two oils rather close together, and it would have been better to have compared pour points as Mr. Larson suggests. This is illustrated in the paragraph of the paper giving reasons for changing oil in cranes.

E. H. THOMPSON.[11]

Baltimore, Md.

[8] MECHANICAL ENGINEERING, December, 1930, p. 1059.

[9] Supervising Engineer, Sinclair Refining Co. Mem. A.S.M.E.

[10] Service Engineer, Detroit Lubricator Co. Mem. A.S.M.E.

Engineering Problems of Modern Motor Cars

TO THE EDITOR:

Col. W. G. Wall's summary of the development and trends in motor-vehicle design in MECHANICAL ENGINEERING for December, 1930, is most comprehensive. However, the writer would like to supplement one statement made by him in commenting on the trend in motor-car brakes to the effect that the hydraulic type of brake seems to be gaining over the mechanically operated type.

Records of sales of passenger automobiles and also of commercial automobiles for the calendar years of 1927, 1928, and 1929 and the first seven months of 1930 show that the great majority of motor vehicles operating today use mechanical brakes, and further that the percentage of vehicles using mechanical brakes is steadily increasing, whereas the percentage using hydraulic brakes has been decreasing.

The following figures are of registered sales of motor vehicles taken from the registrations in the 48 states and represent the sale of new vehicles during the years referred to.

From January, 1927, until the end of July, 1930, the percentage of passenger cars sold that were fitted with mechanical brakes increased from 85.6 per cent in 1927 to 89.1 per cent for the first seven months of 1930. During the same period the percentage of cars sold with hydraulic brakes had decreased from 14.1 per cent in 1927 to 10.8 per cent for the first seven months of 1930.

An analysis of the sales of commercial motor vehicles (that is, motor trucks) sold during the same period (6 months, 1930) shows that such vehicles equipped with mechanical brakes had increased in sales from 77.4 per cent in 1927 to 90.3 per cent for the first six months of 1930. The sale of commercial vehicles with hydraulic brakes stood at 19.3 per cent in 1927, and dropped to 8.7 per cent for the first six months of 1930.

The following tabulation shows the percentages of total sales of passenger cars and commercial vehicles with mechanical brakes and also with hydraulic brakes from 1927 up to Aug. 1, 1930:

	Passenger Cars		Commercial Cars	
Year	Mechanical	Hydraulic	Mechanical	Hydraulic
1927	85.6	14.1	77.4	19.3
1928	85.3	14.3	78.5	19.2
1929	87.6	12.1	87.8	11.1
1930 (7 mo.)	89.1	10.8	....	....
1930 (6 mo.)	....	....	90.3	8.7

The actual sales of cars equipped with mechanical and hydraulic brakes during the same period were:

	Passenger Cars		
Year	Mechanical	Hydraulic	Miscellaneous
1927	2,227,875	366,875	7,164
1928	2,672,755	449,316	12,203
1929	3,398,215	470,272	12,916
1930 (7 mo.)	1,699,601	206,750	1,350
	Commercial Cars		
1927	253,670	63,351	10,835
1928	267,844	65,712	7,746
1929	462,457	58,733	5,578
1930 (6 mo.)	205,900	19,846	2,279

DAVID BEECROFT.[12]

Chicago, Ill.

[11] Lubrication Engineer, Baltimore Copper Smelting & Rolling Co. Mem. A.S.M.E.

[12] Bendix Aviation Corporation.

MECHANICAL ENGINEERING

A Monthly Journal Containing a Review of Progress and Attainments in Mechanical Engineering and Related Fields, The Engineering Index (of current engineering literature), together with a Summary of the Activities, Papers, and Proceedings of

The American Society of Mechanical Engineers

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History of Early Engines

IN 1753 Josiah Hornblower brought a Newcomen engine from England and set it up in New Jersey to pump out a copper mine. This was before the days of Watt's inventions; and the Hornblower engine became the first steam engine to be used in this country. On April 24, 1929, American members of the Newcomen Society of England commemorated this historic event by placing a bronze tablet on the tombstone of Josiah Hornblower located in a churchyard in Belleville, N. J.

Little is known about the history of other early steam engines in this country. Persons who have knowledge of these engines would make worth-while contributions to the history of engineering by seeing to it that such facts as they possess become a part of some permanent record. Communications containing authenticated facts about early steam engines of the Newcomen, Watt, and other pioneer types, or indicating the sources where such information may be found, will be greatly appreciated by the editors of MECHANICAL ENGINEERING and by the American branch of the Newcomen Society. It is important that early records be preserved and made available to students of the history of engineering.

"Forschung"

THIS is the name of a new German periodical issued under the auspices of the German Society of Engineers and succeeding the *Zeitschrift für technische Mechanik und Thermodynamik*. The publication is to cover research (*Forschung*) on a wide scale, and, for example, the first issue contains an article on the observation and measurement of rotating high-speed disks. Another article deals with the thermal properties of ammonia and similar compounds in connection with their application in absorption refrigerating machines. An article on a method of measuring the flow of gas, from a publication by the U. S. Bureau of Standards, is presented in abstract, while other articles deal with the regulation of temperature in industrial furnaces and with investigations in the field of technical hydrodynamics.

Engineers in this country will welcome most heartily the appearance of this new publication. Few activities are of a more truly international character than science and engineering. The heat content of steam at a given temperature and pressure is exactly the same in plants in Chicago and Berlin. The physical laws are the same everywhere. Engineers are engaged in the same problems and can and do without much trouble use any information obtained, no matter where it comes from, so long as it is true. The German Society of Engineers has for a long time vigorously supported and in many cases made possible research on engineering subjects of a very important character, and this new publication will undoubtedly help American engineers to become easily familiar with useful work being done in their field in Germany.

Money for Public Works

THE report of a special committee of the American Engineering Council specifically opposes the proposal for a Federal bond issue of one billion dollars to construct public works.

As the report points out, vast sums have already been appropriated out of Federal, state, and private funds for work of this nature, and the proposed billion dollars is relatively unimportant, compared with these other sums, as a cure for unemployment ills. The floating of such a bond issue would have a serious effect upon our financial condition. Two and possibly three years would elapse before the fund proposed could bring any material relief, and by the time it became an important factor it might be an undesirable one, as, with a return to prosperity, the men, money, and materials involved would be competing with other normal uses.

Great public works, involving the expenditure of a billion dollars, cannot be undertaken without delay. Plans must be prepared, work organized, legal requirements met and objections removed, and condemnation proceedings undertaken before any great amount of money can be spent. If by what seems to be foresight of an unattainable degree, programs of public works involving large expenditures of money could be made effective the instant the need for their stabilizing influence became apparent in the economic life of the country, we should consider ourselves fortunate in having this outlet for men and materials in times of distress; but money that cannot be properly spent for a year or more is not going to keep factories running today nor feed men out of employment.

The Range of Pipe-Line Transportation

SPEAKING before the Des Moines, Iowa, Chamber of Commerce, President Budd of the Great Northern Railway Company is reported to have said: "One characteristic of pipe-line transportation does seem quite definite, and that is that only fluids can be handled advantageously. This is important, and with the necessity for fairly uniform load seems to place such limitations on pipe-line operations that their probable future influence on the railways at least can be estimated."

Investigations have shown that a number of what might be called "quasi" fluids can be carried by pipe line provided the tonnage is sufficiently great. Instances of transportation of such

materials by pipe line over short distances are numerous. A few years ago it was shown that coal could be carried by pipe in a stream of water. There is no technological reason why powdered coal should not be carried by pipe in a stream of air whenever the tonnage to be transported reaches a sufficient volume. The complete problem is, of course, not an easy one, and storage and metering devices will have to be developed. It will then be merely a question of comparative cheapness: lump coal for stokers brought by rail in gondolas, the same lump coal pulverized at the plant, or powdered coal prepared at the mine and delivered by pipe line.

Practically any material in powdered form can be handled by pipe line provided the volume of business is sufficiently large. For example, a considerable amount of cement is manufactured in the Pittsburgh district as a by-product of steel manufacture. Much of this cement is consumed in Philadelphia and New York, and here again there is no technological reason why it should not be transported by pipe in a stream of air. It is not necessary that the same concern should both make the cement and own the pipe line; the latter could easily be a common carrier, provided the grades of cement were properly standardized.

Going further, it is found that it is not at all necessary that the material should be in the form of a fine powder. It has been reported that experiments are being made on conveying grain by pipe, which would be of immense advantage in that the milling would be done close to the centers of consumption and the amount of spoilage in transportation, which is quite high in the shipment of flour, would be greatly reduced.

The Mechanization of Agriculture

A BILL has recently been introduced in the legislature of one of the farming states prohibiting agriculture by corporations. This raises an important question in which mechanical engineers cannot help being interested. Agriculture by corporations is not a new thing in the United States. As a matter of fact, details of the operation of the 95,000-acre Montana wheat farm of the Campbell Farming Corporation were given in the October, 1928, issue of this journal. A special dispatch to the New York *Sun* states that in Kansas at least two corporations are now actively engaged in farming, one cultivating 70,000 acres and the other 35,000 acres. Corporations have for a considerable time been engaged in sheep and cattle raising, and there is unquestionably a strong tendency to go into grain growing.

According to its prospectus, one such corporation in Kansas owns 17,200 acres of land. It would require 53 farmers to till this land, each farmer averaging 320 acres. For maintenance of themselves and families these farmers would require a minimum outlay of $1200 each a year, or $63,600. In the case of the corporation, one operator farms not less than 700 acres and does the work in 90 days at a cost of $4 a day. Thus only 25 men are needed to do the work of 53 farmers operating under the old method, and the yearly payroll is only $9000. These figures are very significant if wholly true.

That large-scale farming with the latest machinery can raise grain at a lower cost than can the old-fashioned farmer-family on a small tract, seems at first sight unquestionable. However, just what is to become of the 28 farmers displaced in the instance cited is a question of great social importance.

Here as everywhere we are facing a situation where mass-scale production, to which agriculture apparently can be made to lend itself, is threatening to reduce the number of men employed and promising to lower the cost of production of the product. Engineers are of course interested in seeing adopted in this country the best methods of production consistent with the best economic and sociological results. The problem, therefore, from an engineering point of view, is not to oppose mechanization of farming as such, but to ease the social shocks caused by mechanization and to develop as quickly as possible additional demands for labor that will help absorb those who are released from production of foodstuffs on the farms.

One possible way of doing this is to develop machinery that will make such specialized lines of agriculture as truck gardening possible. This means not only machinery for farming the truck garden but for preserving the produce raised and transporting it in good condition to the places of maximum demand. As the result of intensive study one such possibility already seems to be indicated, and many others will no doubt develop with the further application of engineering thought to the problem.

More About Automobile Accidents

IN AN EDITORIAL published in these columns not long ago it was stated that one person is killed every year for every thousand cars registered. This formula still holds approximately good, and the only question now left is to determine whether such a comparatively huge number of accidents is within reason.

In the past year there has been a drop in the number of children killed. This is probably due in part to the courses in safety introduced in practically all the public schools, and in part to an increase, particularly in the large cities, of play streets closed to general traffic and playgrounds which take children off the traffic lanes. More adults, however, have been killed, which shows either lack of training in safety among adults or greater peril from traffic. Assuming that children have grown wiser in the ways of avoiding the dangers of our highly mechanized civilization, adults can have hardly become more stupid in this respect, and therefore the increase in the number of accidents to adults can be attributed only to the growing danger of the traffic itself.

This is quite reasonable except for two things. In the first place, with the increase in vehicle traffic the congestion on the streets and highways is becoming greater, leading to an increase of accidents not to pedestrians alone but to users of automotive vehicles themselves. Experts ascribe the growing death rate from automobile accidents to increased speed of car operation, which is only natural. While a car driver may be safely allowed to operate his car at any reasonable speed up to, say, 50 miles an hour, there is no question that when careless and unskilful drivers run their machines at that rate of speed the chances of accidents increase enormously. For example, the New York state commissioner of motor vehicles pointed out some time ago that a large number of accidents result from persons operating their own cars in an improper manner and thereby causing others to suffer.

This increase of speed is all the more apt to lead to an increase of accidents as there has not been a corresponding effort to eliminate from the operators of motor vehicles persons who are inherently incapable of such work. Some states, for example, New York, have an examination for eyesight, but many have not. As far as we know, none of the states has an examination for hearing, and some of them no examinations of drivers at all.

Unless something is done promptly in these respects the accident toll is likely to increase—in the first place because of the fact that cars are becoming bigger and bigger and hence faster and faster, and because the growth of motor-truck transportation, particularly of the long-distance type, which means fast transportation, is imposing a new and heavy burden on the traffic capacity of highways. One man killed and probably 25 to 30 injured for every thousand cars registered—is it really worth while?

Unemployment in Flush Times

THE general impression, particularly among laymen, is that unemployment on a large scale is something new in this country and came about through the series of events beginning with the stock crash in October, 1929, and culminating in the business depression of 1930 As a matter of fact, however, unemployment was quite extensive in 1927–1928 and the early part of 1929. "Middletown," a book published last year and presenting an investigation of a situation in a typical small city in the Middle West, shows what a serious matter it is to a working family to be out of employment. In Middletown, unemployment was largely temporary when the plant laid off men for lack of business, the men usually coming back some time later. There was some technological unemployment as well, particularly among glass blowers who were thrown out of jobs when machine blowing was adopted for bottle making.

A recent publication, "Some People Won't Work," by Clinch Calkins, gives further data about this situation gleaned from investigations of specific cases made by various social settlements in a number of cities, particularly Philadelphia. It is important to remember that the investigations reported in this book deal almost exclusively with the two or three years preceding the stock crash, which were generally considered as boom years. As regards causes of unemployment, several are of particularly striking import. There is the Irish woman who made wire frames for ladies' hats for over thirty years. Then ladies stopped wearing hats requiring wire frames and the Irish woman found herself suddenly out of a job. This is one of the minor (though not to the victim) results of changes in popular demand. That this is not limited to makers of articles subject to the dictates of fashion is indicated by some statistics which the same book presents.

In 1927 the R F Textile Mills employed 5000 workers and produced 137,000 yards of woolens of a certain width, texture, and quality. In 1928, by improved mechanization a labor force of 3000 produced the same yardage of the same cloths. A switching yard of a certain railroad employed 305 men. Two-thirds of the force were skilled or semi-skilled, and about one hundred of these were highly skilled men who had been with the company for from two to nineteen years. Then the switching yard was electrified, and as a result it was found that 151 men could do the work formerly done by 305. Also it was found that less skill and experience on the part of the switching-yard force was necessary under the new conditions, so that of the 154 men laid off, the larger proportion were among the higher-paid group.

It is significant that quite often when the man in the family loses his job, the woman goes to work. Apparently because of the fact that they are willing to work for less, there are jobs for women where there are none for men. In some occupations, as, for example, selling in department stores, women are preferred in certain lines. In other cases, because of the employment of machinery, the job has been simplified to such an extent that neither great physical strength nor particular skill is required, and this in turn opens the door to the woman after the more expensive man has been thrown out.

Again, there is the matter of age. Time after time the author ran across cases where a man had lost his job at forty or forty-five and could not get another one because of his age. When we read statistics about our success in prolonging the average life of workers, it might be well to set them side by side with similar statistics (if available) of men who cannot get jobs because they have exceeded a certain age.

A most significant feature of practically all the cases reported in the Calkins book is that of the large families of the men out of work. Only a very few of them have but two children. Three or four are common, and seven or eight not at all exceptional. Whether or not this has something to do with unemployment cannot be established, of course, without the most careful analysis of each individual case, and such an analysis is not easily possible. It is easy to assume in a general way that a man on a small salary with a family of five or six or seven would be underfed, worried, living under unsatisfactory conditions, and therefore could not do full justice to his job. Hence when a cut in the force came he would be among the first to be thrown out. There is, however, no clear evidence that such is the case, although everything goes to show that the possession of a large family aggravates the situation tremendously when a man loses his job.

In conclusion, it seems fair to ask the following question: If there was steady unemployment even in such boom years as 1928 and 1929 were supposed to be, how long will it be before the several millions of men now unemployed will be reabsorbed by industry, considering that every year new earners are growing up and coming forward to take their places in the ranks of the industrial army?

Direct-Current Transmission

IMPORTANT advances in the art of electrical distribution described by C. W. Stone at the Midwest Power Engineering Conference are of great interest to mechanical engineers. More than a generation ago the controversy over direct and alternating current finally simmered down to a question of high voltages, and for all but local or isolated distribution systems, alternating current won out. Even where direct-current service had been extensively applied, generation and distribution to substation was by alternating current.

The advantages of direct-current transmission at high voltage have always appealed strongly to electrical engineers but have not been realized on account of the impracticability of generation and the difficulty and expense of increasing the generator voltage for transmission after generation and of decreasing the transmission voltage for consumer use. But alternating-current transmission also had its disadvantages, such as the costly and elaborate precautions against reversal of current flow, the necessity of synchronizing generators contributing to a distribution network, the dielectric losses and corona in transmission lines, and such effects as capacity and inductance. A combination system, therefore, whereby alternating current could be generated, transformed to higher voltage, rectified into direct current and transmitted as such, and finally inverted to alternating current and transformed to the lower voltages for consumer use would approach more nearly ideal conditions. Such a system now seems commercially possible.

The means whereby this highly attractive combination system with the actual transmission by direct current at high voltage may be realized is a development of the thermionic valve, one form of which is the familiar radio tube. In the form described by Mr. Stone this valve or tube is known commercially as the "thyratron." This device possesses the ability of passing current in one direction only and, when supplied with alternating current, acts as a rectifier. By suitable connections, two such tubes can be used, one for the positive and the other for the negative half of the alternating-current wave, resulting in the controllable flow of a non-reversible direct current. By changing the connections the direction of current flow can be changed, allowing the current to flow first in one direction and then in the other, so that, with direct current connected to the tube, alternating current will result, and the device becomes an inverter.

The significance of the announcement made by Mr. Stone that his company is now prepared to furnish this form of power tube in capacities up to 9000 kw. is enormous. Forgetting for a moment the cost, about which nothing was said except to

indicate that development work had been and would continue to be expensive and that naturally a new device could not immediately be produced at its ultimately lower price, the thyratron, if it meets the expectations that seem to be justified by laboratory experience, is likely to create a revolution in electrical distribution. Here is a device with a capacity of 9000 kw. that can be carried under a man's arm, that has no moving parts, and that bids fair to replace the substation and its machinery, frequency changers, costly switches and other protective and control devices essential to alternating-current distribution, and that will greatly increase the capacity of electrical conductors as well as the efficiency of transmission. If these and other expectations are realized we are apparently entering a new era in the electrical power industry.

Railroad Consolidation

SOME fourteen men met in New York just before the beginning of the new year and decided the fate of an important group of railways in the United States. Investments of around $12,000,000,000 were involved—more, probably, than the wealth of some of the large European countries two generations ago—and transportation systems that serve a region containing a larger population than the whole of the United Kingdom. Here was an illustration of the concentration of management and not of wealth, because, outside of the Van Sweringen brothers, the other members of the conference on the consolidation of certain railways east of the Mississippi River into four trunk-line systems were not multimillionaire owners of railroad securities, but for all practical purposes were employees of an especially high type.

It would be unwise to assume that the consolidation is an accomplished fact. Many points of great importance still remain to be settled, and an even more dangerous obstacle has to be hurdled, namely, the pronounced opposition of certain powerful elements in the United States Senate.

What advantages from an engineering point of view are involved in the four trunk-railroad consolidation? This is an important matter for the entire engineering profession. In the first place, it may be safely assumed that the merger will increase the efficiency of operation of the railroads involved. It will provide what might be called straighter lines from point to point, and will give entry to each of the systems into important shipping centers hitherto more or less monopolized by one or more of the other lines. Thus, for example, the Baltimore and Ohio will gain a direct entrance into New York, and, through the allocation to it of the Ann Arbor Railroad, also into Detroit. The Pennsylvania will obtain trackage over certain parts of the Nickel Plate, and is expected to get a terminal in Buffalo. The increase in efficiency thus produced will be helpful to industry throughout the United States, and therefore to the engineering profession.

There will also result a resurvey of methods of operation, management, and, in particular, maintenance of rolling stock. As a result of the allocation of various lines to the main units of the four trunk systems there will be important changes, for example, in the assignments to the various roundhouses. Methods of operation and maintenance of rolling stock are likely to be standardized throughout the newly created systems, involving a considerable amount of work and some time.

That these changes may lead to a certain amount of pruning of the engineering staffs is to be expected. They will also lead to a considerable amount of new construction. Junction points for the old systems and their new accessions will have to be developed. It is expected that permission to the Baltimore and Ohio Railroad to enter New York City will result in the construction of a bridge across the Hudson river at 59th Street. This project was worked out some time ago, but was not undertaken because of the opposition of other railroads and of certain requirements of the War Department which were considered unacceptable to the Baltimore and Ohio at that time.

As regards labor, Senator Couzens of Michigan, in an interview given to the papers, quoted a statement alleged to have been made to him by Daniel Willard, president of the Baltimore and Ohio Railroad Company, to the effect that it would appear, in Mr. Willard's opinion, that this consolidation will not result in the employment of a greater number of men. That the main savings resulting from the consolidation can and will be effected through a reduction of the number of men employed to carry on the business, seems to be logical. It does not mean, of course, that the railroads will institute a wholesale reduction of their employees. The process of improving the efficiency of operation will not be carried through over night but will take time—months, probably years. During this period some of the men who leave the service because of ill health, death, or other reasons, will not be replaced. As this process has been going on during the last four or five years, railroad consolidation may merely accelerate it.

It should be remembered, of course, that the consolidation of the eastern lines is at present very far from being an accomplished fact. In the first place, there has been as yet no complete agreement between the parties, and certain very important matters have been left to future decision by arbitration. This applies in particular to Pennsylvania's entry into Buffalo and its trackage rights over certain parts of the Nickel Plate system. In the next place, while the approval of the consolidation scheme by President Hoover signifies much, it does not by any means insure the acceptance of the plan by the Interstate Commerce Commission.

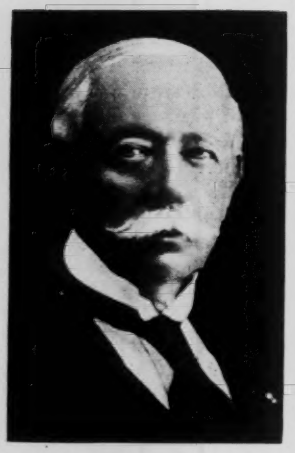
Even assuming, however, that the I.C.C. hurdle has been safely taken, there is still a danger of further delay in the possibility of minority stockholders of the various lines involved bringing court action against the consolidation or appearing as objecting parties at the hearings before the Interstate Commerce Commission. It is well known that several of the consolidation schemes of the Van Sweringen brothers have come to grief because of objections raised by minority stockholders of the Chesapeake and Ohio Railroad. This group of objectors have apparently been pacified, but it would be very unusual, indeed, were a consolidation of the magnitude of the proposed scheme to go through without some one taking the matter to the courts. In the case of the Chicago, Milwaukee, St. Paul and Pacific, the objecting stockholders delayed the transaction but could not prevent it. The decision of Judge Jenkins in the Bethlehem-Youngstown merger, however, has added much to the confidence of minority stockholders, though none of the issues of the steel merger can possibly be involved in the railroad consolidation matter. It must be remembered, however, that a very large number of companies are involved in the consolidation and that they exist under the laws of different states; some of them were incorporated at a time when the statutory provisions for voluntary liquidation and sale of assets were quite unusual, and it would therefore be extremely difficult to find anything in their procedure that prima facie would be legally objectionable.

"Engine-Room Stuff"

THE next time that non-engineer friend begins his argument about robots and men becoming enslaved by machinery, ask him to read "Engine-Room Stuff" in the February *Harpers*, an account of a ship that "committed suicide" and the men who saved their own lives and those of the passengers entrusted to them. It is a story of the sinking of the *Tahiti;* told by a man who can use the English language effectively and who knows engine rooms—William McFee.

Luigi Luiggi

1856–1931



LUIGI LUIGGI

LUIGI LUIGGI, senator of the Kingdom of Italy, noted Italian engineer and a recipient of the A.S.M.E. Fiftieth Anniversary medal in 1930, died February 1, 1931, of apoplexy at the age of 74. He was honorary president of the National Council of Public Works of Italy; professor of hydraulic and maritime engineering at the Royal University of Rome; consulting engineer for harbors, rivers, and canals; and had served as inspector general of the Royal Corps of Civil Engineers. He was also a member of the Royal Privy Councils for Education, for Scientific Researches, and for Irrigation and Navigable Canals, and had been director of the State Railways of Italy and a member of the Italian Parliament for his native city, Genoa. He was appointed national senator for life in 1924.

To readers of MECHANICAL ENGINEERING he will be remembered for his participation in the Fiftieth Anniversary Celebration of the A.S.M.E. last April. On that occasion he was the official representative of the Rome Ministry of Public Works; the Royal Colleges of Engineering of Turin and of Rome, the Royal College of Naval Engineers, and the National Fascist Society of Engineers. He was the author of the Italian monograph and received one of the Fiftieth Anniversary Medals. He was also president of the Italian delegation to the World Engineering Congress in Japan in 1929.

Dr. Luiggi was born in Genoa in 1856. He received the degree of D.Eng. from the Royal University of Turin; Hon.D.Sc. from the University of Melbourne, Australia; and Hon.D.Eng. from Rensselaer Polytechnic Institute, Troy, N. Y.

Dr. Luiggi began his career in the Royal Corps of Italian Civil Engineers as resident engineer for the harbor works of Genoa, where from 1882 to 1892 he had charge of the construction of the great breakwaters. The next year he served as technical secretary to the Minister of Public Works, when he was sent on a special mission to Denmark and then to the United States to study the working of railway ferryboats, which he applied to the crossing of the Strait of Messina. He was then promoted to the position of engineer-in-chief, and took charge of the harbor works of Tuscany during 1894–1895.

In 1896 he was invited by the Argentine Government to serve as consulting engineer and take charge of its then new naval dockyard at Bahia Blanca, which latter he designed and carried out with its numerous and extensive harbor constructions, including graving docks, piers, hospital, barracks, various buildings, and military works. During his residence in Argentina Dr. Luiggi built a complete system of lighthouses and telegraph and semaphore stations along the coasts of Patagonia, from Bahia Blanca down to the extreme southern end of the continent. He also acted as consulting engineer for the new harbor works of Buenos Aires, Mar del Plata, Rosario, Sante Fe, Montevideo, and Rio Grande do Sul, besides reporting on several canals for inland navigation and irrigation of the pampas.

Having completed his engagement to the entire satisfaction of the Argentine Government, Dr. Luiggi returned to Italy in 1905, where he resumed his post in the Royal Corps of Civil Engineers as inspector general. In the meantime he also was elected member of the Board of Directors for the Italian State Railways, and professor of hydraulic engineering at the Royal University of Rome. At various times he was sent by the Italian Government to inspect and prepare plans for the improvement of the harbors of Massawah and Assab in the Red Sea, and Ras Filuck, Mogadiscio, and Brava in Somaliland. When Italy occupied Libya he was also entrusted with the projects and works for the harbors of Tripoli, Bengazi, Derna, and Homs, and for a system of lighthouses all along that coast, and he carried out these works with exceptional rapidity.

From 1913 on he was a member of the International Technical Commission for the Suez Canal, and of the European Commission for the Navigation of the Danube. In 1923 he was called by the Egyptian Government to prepare plans for the improvement of the harbors of Suez and Alexandria, and again in 1926 for the harbors of Damietta and Rosseir. In 1925 the Aegean and Albanian Governments entrusted to him the improvements of the respective harbors of Rhodes and Durazzo, and in 1929 the Greek Government sought his services for the harbors of Candia, the Piraeus, and Saloniki.

At various times during his life the Italian Government appointed Dr Luiggi official delegate to the International Congresses of Navigation and of Engineering, held at Frankfurt, Manchester, Paris, Chicago, London, Petrograd, Buenos Aires, Philadelphia, San Francisco, and Tokyo. As high commissioner he also was given entire charge of the arrangements for the Italian Exhibition held at Buenos Aires in 1910.

Dr. Luiggi was very conversant with English, French, Spanish, and German; and traveled extensively all over Europe, North and South America, and also in the East, where he visited for professional purposes, Cyprus, Greece, the Holy Land, Egypt, Abyssinia, India, China, and Japan.

In 1914 he also visited Australia as honorary guest of the British Association for the Advancement of Science, and delivered several lectures on irrigation works in Italy at the Universities of Adelaide, Sydney, and Melbourne. In 1921 he was invited by the University of London to give a series of lectures on the latest engineering works in Italy, dealing especially with Italian hydroelectric works, some of which are extremely interesting, and in 1924 he delivered a number of lectures at the Rensselaer Polytechnic Institute, of Troy, N. Y. He also lectured before several learned societies in Japan.

Dr. Luiggi was an honorary member of the American Society of Civil Engineers; a member of the Institutes of Civil Engineers and of Structural Engineers of London; of the Collegio degli Ingegneri of Genoa, and of the Centro Nacional de Ingenieros of Buenos Aires; and honorary correspondent member of the Sociedad Cientifica Argentina.

Dr. Luiggi devoted much time to research work upon the force of sea waves and their effects on breakwaters; and also on concrete, reinforced concrete, pozzolanic cements, and other materials best adapted to resist the corrosive action of sea water. The most important are on "possolana" and "pozzolana mortars," upon which he was an authority in Europe; and on "pozzolanic cement" for making concrete blocks for harbor works cheaper and more durable in sea water than ordinary blocks made with normal portland cement. He also experimented on the adhesion of concrete to iron, both clean and rusted, and on the type of reinforced concrete best adapted for piers, caissons, and other maritime constructions. He was the author of many technical papers on various subjects, especially on hydraulic construction, including one on the Apulian Aqueduct, in Southern Italy—the longest and most difficult to construct in the world.

Dr. Luiggi received the three honors of Grand Commander

of Saint Maurice, of the Crown of Italy, and of the Star of Italy for distinguished services; also a medal for the Campaigns of Abyssinia in 1882–1884, of Libya in 1911–1912, and of the Allies for the Great War. He also received a gold medal for services rendered as member of the Munition Board, on which he served as honorary colonel of engineers, and a silver medal for special meritorious services to the Italian Red Cross. He was Officer of the Légion d'Honneur of France and the Grand Cross of Greece, and received several gold medals and tokens of merit from the Italian societies of Bahia Blanca and Buenos Aires for his activities in Argentina. The Argentine Government for the same reason decreed that a town in the pampas should be called "Ingeniero Luiggi," which is now very prosperous, with more than 12,000 people, and the city of Bahia Blanca gave his name to one of its principal streets, and honored him with the freedom of the city.

Dr. Luiggi, or Senator, as many of his American friends knew him, was married in 1887 to Miss Annie East, of Lincoln, England, and had two children, a daughter, Luise, and a son, Dr. Mario L. Luiggi, D.Eng., of Italy, married to a Miss Houston of Kansas City, and mechanical engineer to the General Motors Corporation.

Book Reviews and Library Notes

THE Library is a cooperative activity of the A.S.C.E., the A.I.M.E., the A.S.M.E., and the A.I.E.E. It is administered by the Engineering Foundation, Inc., as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West 39th St., New York, N. Y. In order to place its resources at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references on engineering subjects, copies of translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

The Library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

A Course in English for Engineers

A COURSE IN ENGLISH FOR ENGINEERS. By Carl A. Naether and G. F. Richardson. Ginn and Company, Boston, Mass., 1930. Cloth, 6 × 9, Vol. 1, 330 pp., $2.60; Vol. II, 488 pp., $3.

REVIEWED BY SADA A. HARBARGER[1]

THIS work consists of two volumes closely packed with discussion of general rhetorical principles and of the technical man's professional and business (mostly business) writing, and with illustrative material "of genuine interest" to an engineer. The authors present with encyclopedic thoroughness subject-matter for English courses in composition in a technical school. But in the attempt to be of service to both the practicing engineer and the undergraduate, the differences in experience and immediate needs, especially those of the undergraduate, have not been sufficiently recognized nor adequately differentiated.

Volume I, "The Engineer's Speaking and Writing—In General," has been aptly described as a "dissertation," for it treats in academic manner the types of discourse and the general qualities of writing. Like the practicing engineer, who assumes that his thorough grasp of his subject and his extended experience will make the mere presentation of his facts and figures intelligible and interesting to the non-technical reader, the author of this volume—despite selections with a technical slant and direct reference to engineers—has retarded interest in his specialty, English, for he has not selected those essentials of composition which have special significance to his technical reader. While the discussion is abstract, the material of the exercises—excerpts from all phases of engineering—has been well selected for extending the thought of the engineer in engineering. Its value, however, would be further enhanced if some of the material had been inserted at appropriate places in the body of the chapters to make vivid the generalizations. Undergraduates, whose interest is unaroused and whose experience is limited, cannot be expected to supply concrete examples to round out the abstract discussion of principles. Even for the practicing engineer, the technical names of errors, the identification of various forms of discourse are of less moment than definite information on moot points of usage, and the specific technique necessary to secure concise, coherent, and orderly presentation, together with concrete suggestions for meeting the problems of writing that confront him when he writes his next report. Only when he has become sufficiently skilled as a mature writer, is he able to take a detached point of view and to want to philosophize on the underlying abstract theories of English.

Volume II, "The Engineer's Professional and Business Writing," has for its purpose "a concise but comprehensive statement showing how to apply the principles of commercial correspondence to every sort of important business letter—always, of course, from the engineer's point of view dealing with the engineer's work but regardless of the particular nature of that work." This volume has much of the desirable concreteness so lacking in Volume I. In fact, more interest would be aroused if the engineer were introduced to his English study through Volume II. The first section, particularly, on the general principles, gives helpful information on present-day practice in business writing. In the succeeding sections, practically every type of commercial communication is included on the assumption that "since the majority of engineering students do not become professional engineers but enter the employ of manufacturing and other similar firms, they will need to know the principles underlying the writing of any important business letter." While admitting the need of knowing the underlying

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principles, the teacher might well question whether the demand for knowing in detail the letter of credit, claims, adjustment, and collection is sufficiently widespread in the professional activities of most engineers to require more than passing reference in a text for undergraduates. For them the many divisions of business should be reduced, and the mass of material simplified. Yet regardless of the fact that this volume is to meet the needs of engineering students, most of the direct references and the illustrative material are to and for "the professional engineer and the engineer employed by a manufacturing or other firm;" the attitude is that of the correspondence supervisor or the consultant in business writing rather than that of the teacher of undergraduates. The excellence of this volume is therefore in the splendid analysis of particular types of letters, and in the practical general outlines for them. Indeed, the author is at his best when he is diagnosing concrete situations and criticizing individual letters. Taken as a whole, Volume II is a very desirable reference book on commercial writing for any professional engineer, business man, or teacher. The restriction implied in its title—"for engineers"—will perhaps limit the book's usefulness. Its very comprehensiveness impairs its value for undergraduates.

Books Received in the Library

ACOUSTICS: A Text on Theory and Applications. By George Walter Stewart and Robert Bruce Lindsay. D. Van Nostrand Co., New York, 1930. Cloth, 6 × 9 in., 358 pp., diagrams, tables, $5.

The increasing use of acoustical apparatus has created a need for better understanding of the theory of acoustics. The present book aims to meet the need by providing a clear exposition of the theory, in which modern applications are kept to the fore. The book is intended to provide the equipment necessary for attacking mathematically the problems that confront the designer of telephone equipment, the architect, and other investigators.

AIRCRAFT PROPELLER DESIGN. By Fred E. Weick. McGraw-Hill Book Co., New York, 1930. Cloth, 6 × 9 in., 294 pp., illus., diagrams, charts, $4.

Aims to present the experimental, theoretical, and practical developments in propeller design during the past decade, in a simple usable manner. The influence of airplane and engine design upon propulsive efficiency is emphasized. A simple method of selecting propellers for any given condition is presented.

A CENTURY OF WOOD PRESERVING. Edited by Sir Harold Boulton. Philip Allan & Co., London. 1930. Cloth, 6 × 9 in., 150 pp., plates, 8 s., 6 d.

A collection of papers upon wood preservation, especially by creosoting, which form an account of the development of the art during the hundred years that have passed since John Bethell became interested in the subject. Bethell's patent is given in an appendix, and there is a long list of references on wood preservation.

COMPARISON OF THE PHYSICAL PROPERTIES OF VARIOUS KINDS OF CAST-IRON PIPE. By F. N. Menefee and A. E. White. (University of Michigan, Department of Engineering Research. Reprint series No. 6.) Ann Arbor, Mich., 1930. Paper, 6 × 9 in., 41 pp., diagrams, tables, $0.50.

Specimens of centrifugally cast, horizontally cast, and vertically cast six-inch and eight-inch pipe were tested by the authors to determine their relative serviceability for water mains. The tests are described in detail and general conclusions are drawn.

COMPRESSED AIR PLANT: The Production, Transmission, and Use of Compressed Air. By Robert Peele. Fifth edition. John Wiley & Sons, New York, 1930. Cloth, 6 × 9 in., 534 pp., illus., diagrams, tables, $7.50.

The many changes in compressed-air practice since the fourth edition of this book appeared, in 1920, have led to the rewriting of most of the work. Chapters are devoted to cylinders, valves, governors and unloaders, to compressor design, operation, and costs. The conveyance of compressed air and its use for drilling rock, cutting coal and stone, pumping, and haulage are treated. Chapters are devoted to the performance of rock drills and to drill bits and mechanical sharpeners. The book describes current practice in the design and use of compressed-air machinery very thoroughly.

DETAILING AND FABRICATING STRUCTURAL STEEL. By F. W. Dencer. Second edition. McGraw-Hill Book Co., New York, 1930. Cloth, 6 × 9 in., 441 pp., illus., diagrams, tables, $5.

This is the most extensive work available upon structural-shop practice. Engineering and shop organization, designing and specification writing, the various steps and processes of fabricating, the inspection, and shipping of work are discussed in the light of practical experience. The book should be useful to all who have to do with the design and construction of steel structures. The new edition has been extensively revised and new matter has been added.

DIESEL POWER PLANT HANDBOOK (formerly the Oil Engine Plant Handbook). By Julius Kuttner. Sixth edition. *Diesel Power*, New York, 1930. Fabrikoid, 8 × 11 in., 280 pp., illus., $5.

The text of this edition consists of a practical course on the operation and maintenance of Diesel engines, which should meet the ordinary requirements of the engine room. In addition the book contains condensed descriptions of the Diesel engine manufacturers of the United States.

DER EINKAUF IN DER METALLINDUSTRIE. By Bertold Buxbaum. V.D.I. Verlag, Berlin, 1931. Cloth, 6 × 8 in., 153 pp., illus., forms, 12.50 r.m.

Points out the advantages of planned, systematic purchasing methods and discusses the fundamentals of purchasing-department organization. The presentation is applied to machine shops, but the principles laid down are general.

ENGINEERING METALLURGY; A Text-Book for Users of Metals. By Bradley Stoughton and Allison Butts. Second edition. McGraw-Hill Book Co., New York, 1930. Cloth, 498 pp., illus., diagrams, tables, $4.

An elementary course in metallurgy, aimed at the needs of the engineer who uses metals, rather than the one who produces them. Emphasis is placed on the effects of impurities, working, heat treatment, methods of production, molecular structure, composition, etc. upon the properties of the common metals and alloys. The new edition has been revised and enlarged.

GEOMETRISCHE TRANSFORMATIONEN. By Karl Doehlemann. Second edition, edited by Wilhelm Olbrich. Walter de Gruyter & Co., Berlin and Leipzig, 1930. Paper, 6 × 10 in., 254 pp., 13 r.m.

Aims to present an introduction to the entire field of geometric transformations within a single volume, and in not too abstract a manner. The uses of the subject in dealing with problems of physics, machine design, and building are pointed out.

HYDRAULICS FOR ENGINEERS AND ENGINEERING STUDENTS. By Frederick Charles Lea. Fifth edition. Longmans, Green & Co., New York, 1930. Fabrikoid, 775 pp., illus., diagrams, tables, $7.50.

The new edition of this well-known textbook apparently has been entirely reset, and in the process the accumulated

appendixes have been incorporated in the text. A considerable amount of material upon recent researches and developments and a chapter on dynamic similarity have been added. The book offers a clear, practical exposition of the fundamentals of hydraulics, with illustrations of their applications to water wheels, pumps, and hydraulic machines, and to the measurement of the flow of water.

INDUSTRIAL HISTORY OF THE UNITED STATES. By Witt Bowden. Adelphi Company, New York, 1930. Cloth, 6 × 8 in., 511 pp., $4.

A very readable one-volume account of our industrial growth from the period of discovery to the present day. The economic forces governing each epoch are clearly indicated and their influence upon our industrial development shown. The general reader, as well as the student, will find the book of interest.

KRAFT UND WÄRME IN DER LANDWIRTSCHAFT UND IN LANDWIRTSCHAFTLICH-INDUSTRIELLEN BETRIEBEN. By W. Leder. (Wärmelehre und Warmewirtschaft in Einzeldarstellungen, bd. 9.) Theodor Steinkopff, Dresden and Leipzig, 1930. Paper, 6 × 9 in., 222 pp., illus., diagrams, 18.50 r.m.

A reference book upon the uses of machinery in agriculture. Farm motors and engines, the use of machinery in dairies, the drying and distilling of farm products, are described and the economics that they make possible are shown.

MAN AND THE STARS. By Harlan True Stetson. Whittlesey House, McGraw-Hill Book Co., New York, 1930. Cloth, 6 × 9 in., 221 pp., illus., $2.50.

A readable account of the development of man's conception of the universe, from the earliest times to the present day. The work of the great pioneers is described, our modern ideas of the heavens are explained, and the possibility of life on other planets is discussed. Intended for the general reader interested in the extent and nature of the universe.

MANUFACTURE OF STEEL SHEETS. By Edward S. Lawrence. Penton Publishing Co., Cleveland, Ohio, 1930. Cloth, 6 × 9 in., 233 pp., illus., diagrams, $6.15.

Describes the sequence of operations in sheetmaking from the manufacture of the steel to the finished sheet, with especial reference to the production of high-grade sheets for automobile bodies. The influence of various methods upon the quality of the product and the causes and prevention of defects are given attention. The description follows current practice and is devoid of unnecessary technicalities.

THE METALLURGY OF BRONZE. By H. C. Dews. Isaac Pitman & Sons, New York, 1930. Cloth, 6 × 8 in., 147 pp., illus., diagrams, tables, $3.75.

A brief summary of our theoretical and practical knowledge of the metallurgy of the bronzes, with particular reference to the problems that confront the foundryman. The cast structure of the bronzes and their properties are described. The effects of lead, nickel and minor constituents, and of gases and casting temperature are discussed. Chapters are devoted to foundry practice and to segregation and liquation.

PATENT RIGHTS FOR SCIENTIFIC DISCOVERIES. By C. J. Hamson. Bobbs-Merrill Co., Indianapolis, 1930. Fabrikoid, 6 × 9 in., 286 pp., $5.

This monograph, which received the Charles C. Linthicum Foundation prize in 1929, discusses the important new legal idea of "scientific property." The author reviews the historical development of the idea and past attempts to protect the rights of discoverers of scientific facts, and discusses the problems that arise in formulating a law to protect discoverers. The draft of a proposed statute is given and the objections to it discussed.

PRINCIPLES OF ENGINEERING THERMODYNAMICS. By Paul J. Kiefer and Milton C. Stuart. John Wiley & Sons, New York, 1930. Cloth, 6 × 9 in., 545 pp., $4.50.

Intended as a basic and fairly comprehensive analysis of those aspects of thermodynamics which are required in the design and operation of machines for producing and transforming power. The subject is treated in five sections. The first discusses the First Law of thermodynamics, with emphasis upon the distinctive characteristics of stored and transient forms of energy, and of the energy equation as it applies to steady-flow machines. The Second Law and the Carnot principle are then treated, the availability of energy and the physical significance of entropy being emphasized. Part three describes the physical properties of vapors and gases and mixtures of them. Part four analyzes motive-power machinery and certain power-using apparatus with the principles previously developed. The final part develops the general thermodynamic equations.

PRINCIPLES OF PATTERN AND FOUNDRY PRACTICE. By William H. Richards. McGraw-Hill Book Co., New York, 1930. Cloth, 6 × 9 in., 121 pp., illus., $1.60.

A course intended to give the engineering student a working knowledge of some of the problems found in general pattern and foundry practice. A series of graded exercises introducing the essential features of pattern construction are included, together with brief lectures upon the principles of pattern and foundry practice in relation to engineering problems.

PUNCHES, DIES AND TOOLS FOR MANUFACTURING IN PRESSES. By Joseph V. Woodworth. Fourth edition. Norman W. Henley Publishing Co., New York, 1930. Cloth, 6 × 9 in., 538 pp., illus., diagrams, $5.

A reference book for die makers and tool makers. A great variety of dies for shaping, punching, and cutting metals are described and their use illustrated. Many shop kinks are given.

RECHNUNGSWESEN IM MASCHINENBAU. By Herbert Peiser. V.D.I. Verlag, Berlin, 1930. Cloth, 6 × 8 in., 114 pp., 5 r.m.

A concise discussion of the fundamental principles of factory accounting. The author aims to differentiate clearly the various costs that enter into the cost of a machine and to show how these may be ascertained and allocated. The book is endorsed by the Committee on Factory Accounting of the Society of German Engineers.

TECHNICAL DATA ON FUEL. Edited by H. M. Spiers. Second edition. British National Committee, World Power Conference, London, 1930. Cloth, 5 × 8 in., 242 pp., diagrams, tables, $2.75.

This volume contains data upon the properties of air, water, gases, steam, metals, refractories, and fuels. Tables of the specific heat and thermal conductivity of fuels and furnace materials are given, and such matters as stack losses, pyrometers, viscosity, and the flow of gases are discussed. Much information constantly needed by fuel users is brought together in convenient form. The new edition is considerably enlarged. Distribution of the book in the United States is handled by the American Committee of the World Power Conference, 405 Lexington Ave., New York, to whom orders should be sent.

TEXTILE MECHANICS AND HEAT ENGINES. By Arthur Riley and Edward Dunkerley. Isaac Pitman & Sons, New York, 1930. Cloth, 6 × 9 in., 286 pp., illus., diagrams, $4.50.

Elementary mechanics and heat are presented in this concise text, which is intended for students of cotton spinning. Emphasis is naturally given to subjects directly connected with textile manufacture, and the problems and illustrations are drawn from that field.

Synopses of A.S.M.E. Transactions Papers

THE papers abstracted on this and following pages appear in the current issues of the Fuels and Steam Power, Machine Shop Practice, and Railroad sections of A.S.M.E. Transactions. These sections have been sent to all who registered in the similarly named Divisions. Other sections are in the course of preparation and will be announced, when completed, in later issues of "Mechanical Engineering."

FUELS AND STEAM POWER PAPERS

A Calorimetric Determination of Thermal Properties of Saturated Water and Steam From 0 Deg. Cent. to 270 Deg. Cent. By N. S. Osborne, H. F. Stimson, and E. F. Fiock. [Paper No. FSP-52-28]

In this paper a description is given of the method, apparatus, measurements, results, and formulations involved in the work on steam which has been completed to date at the Bureau of Standards. The method has been developed in accordance with the principles set forth in a rigorous analysis of the thermodynamic processes involved in a change in state of a saturated fluid. The apparatus has been designed and built to provide a means for accurately controlling, observing, and accounting for the amount, the change in state, and the change in energy of a sample of water.

The observations have been carried out as a systematic series of experiments in the range from 0 deg. cent. to 270 deg. cent. (to 55 atmospheres pressure), yielding as a result the values of three characteristic thermal properties of the saturated fluid.

The formulation of the results establishes the values of heat content, latent heat, and entropy, and constitutes an exhibit of the thermal behavior of saturated steam in the region covered by the experiments. The results are assembled in a coherent, consistent table of the properties of steam, available as a foundation for a more complete steam table. It is found that, when reduced to a uniform basis, after critical study and analysis, most of the source data on saturated steam are in satisfactory accord.

Calorimetry of a Fluid. By Nathan S. Osborne. [Paper No. FSP-52-29]

A rigorous analysis of the thermal processes involved in the change of state of a saturated fluid shows that four types of calorimetric processes each yield values of a characteristic thermal property of the fluid. This group of calorimetric properties may be used to formulate the thermal behavior of the fluid in terms of familiar and convenient properties within the range of the experimental possibilities.

The principles of a calorimetric method of determining the thermodynamic characteristics of a fluid are outlined. The method has been developed at the Bureau of Standards and used in the determinations of the properties of saturated water and steam, published simultaneously with this paper. This paper supplements that report and furnishes the theoretical groundwork for the experimental work.

The results of the analysis have been used as a guide in developing a systematic experimental project which has resulted in the determination of an important group of properties of saturated steam.

A Review of Calorimetric Measurements on Thermal Properties of Saturated Water and Steam. By Ernest F. Fiock. [Paper No. FSP-52-30]

This review has been prepared to assemble the data which are now available on the calorimetric determinations of the thermal properties of saturated water and steam, and to reduce them to a uniform basis for comparison. After a careful analysis of the reports which have appeared in the literature, an attempt is made to point out some possible causes for the variation among the recorded results. Wherever it seemed desirable a thermodynamic interpretation of the experiments is given, and in a number of cases the data have been recalculated. By these means the agreement among the various determination has been improved in several instances.

It is hoped that this assembly of results presented on a uniform basis may serve as an aid to future International Steam Table Conferences in the choice of base values and tolerances for the International Skeleton Tables.

By means of deviation charts the experimental values for the heat content or enthalpy of the saturated liquid and for the latent heat are exhibited and compared. The agreement is in general quite gratifying.

Several modern steam tables are compared graphically with one another and with the Bureau of Standards experimental results on the thermal properties of the saturated liquid and vapor. A marked improvement in the tables is evident with the increase in scope and the reliability of the basic experimental data.

Effect of Large Boilers at High Capacities on Operating Characteristics and Investment in Boiler Plants. By Frank S. Clark. [Paper No. FSP-52-31]

This paper treats of the various factors that enter into the design of boiler plants, their effect on investment costs and on operating characteristics. It traces the development of the boiler plant from a number of small units operated at moderate capacities to the present plant of a few large units run at high rates of evaporation. It gives the conditions that limit the sizes and output and shows how, as the demand for larger units increases, these conditions have been overcome. The paper shows the effect of large units in reducing the sizes of buildings to house them, and the number of auxiliary equipment to serve them. It shows the effect of reliability of equipment on increased service factor, with consequent reduced necessity for spare equipment. It states that the governing factors in investment costs for a given condition are the size of the unit and the output obtainable, the former depending on the ability to manufacture, and the latter on the fuel that can be burned in the furnace and the ability of the unit to absorb the heat. Further, it discusses the proportioning of heat-absorbing surfaces between boiler, economizer, and air preheater to obtain the most economic result at minimum cost, and also the effect on operation of large units run at high capacity, and in turn their effect on labor and maintenance cost.

Flow Characteristics of Some Lead Cable Sheath at Temperatures Above Atmospheric. By C. L. Clark and C. Upthegrove. [Paper No. FSP-52-32]

This paper gives results of an investigation on three types of lead cable sheath differing only in the antimony content, which was, respectively, 0.06, 0.6, and 1.2 per cent. At room temperature all three compositions elongated at more or less fixed rates with loads as low as 245 lb. per sq. in. The results would indicate that a similar behavior would be obtained with still lower loads, and that the behavior of lead at 70 deg. fahr. should be similar to that of plain carbon steel at a temperature above its equicohesive range.

Increasing the antimony content does not result in a decrease in the rate of flow at the lower temperatures, but in a lowered resistance to creep. At a temperature of 80 to 120 deg. cent. the high antimony content results in a decrease in the rate of creep, while the lower antimony results in a comparatively high rate of creep.

The Heat-Balance Test as a Means of Obtaining Evaporative Efficiencies of Steam-Generating Equipment. By B. J. Cross. [Paper No. FSP-52-33]

The efficiency of any energy-converting apparatus is determined by a division of the energy output by the energy input. In the case of boiler and furnace this is attained by weighing the coal or other fuel and weighing the water evaporated. The paper attempts to show that the efficiency as determined by the heat-balance method should have equal value with an efficiency as obtained by the test of weighing the coal and water.

The Performance of Modern Steam-Generating Units. By C. F. Hirshfeld and G. U. Moran. [Paper No. FSP-52-34]

There has been much speculation during the past as to those factors which seem to be most responsible for steam-generating-unit outage. Some have held that the outage increases directly with the severity

of use. Others contend that the method of burning the fuel has a definite bearing on reliability. Others still have set different values for unit reliability on different kinds of fuel.

The study was made along the same general lines as the steam-turbine investigation made by the Prime Movers Committee of the N.E.L.A. The methods used in collecting information were as nearly identical as circumstances and the character of the units studied would permit. Daily operation logs were filled out for the period of one year by the operators of some two hundred boilers scattered about the country in sixty-odd stations. The data resulting were compiled by one group of men in such a manner that the results might be readily compared.

WORKING STRESSES FOR STEEL AT HIGH TEMPERATURES. By D. S. Jacobus. [Paper No. FSP-52-35]

Certain of the published results for the stress to produce creep at higher temperatures have led to apprehension in the employment of stresses that have been used, and it is the object of the paper to dispel such apprehension for the particular stresses which are discussed.

The results secured in practical experience are used for setting the maximum working stresses for drums and superheater headers up to temperatures of 800 deg. fahr., and for temperatures above 800 deg. fahr. the working stresses are scaled down in proportion to the falling off of the stresses that produce creep. The first curve of creep stresses published by H. J. French of the Bureau of Standards was used, and the working stresses for a given temperature are taken at $^2/_3$ the creep stress. The effect on the stress of piercing a boiler shell with holes and of transmitting heat through the shell is discussed, as well as the tendency toward equalization of stress through extension of the most-strained fiber. The tendency of the creep to equalize the stresses is also brought out.

THE BIN SYSTEM OF PULVERIZED COAL. By Henry Kreisinger. [Paper No. FSP-52-36]

The advantages of the bin system for handling pulverized coal are given as follows: Dependable feed of coal to furnace within a wide range of rating of the boiler. Easy adjustment of primary and secondary air. Coal can be pulverized in the off-peak period. Mills can always be operated at full rating. Uniform fineness of coal. Breakdown of mill does not interfere with boiler operation. Increased moisture or ash content does not affect maximum steam output of boilers. Wear on mill does not affect fineness of coal nor capacity of boiler. Clean and noiseless boiler room. High thermal efficiency of boiler plant.

THE PURPOSE AND CHARACTERISTICS OF THE AIR-FLOW MECHANISM OF A BOILER METER. By W. G. Lauffer. [Paper No. FSP-52-37]

Stack loss in a modern steam-generating station is assumed to be a controllable item effected by the installation and use of combustion guides. The paper reveals the probability of error in such an assumption. The air-flow mechanism of a well-known boiler meter, the proper operation and calibration of which have probably not been understood, is given a detailed study in this report, and the work accomplished is described as resulting in an indicator of combustion efficiency that is reliable within close limits.

POWER AND HEAT IN THE INDUSTRIAL PLANT. By R. J. S. Pigott. [Paper No. FSP-52-38]

The author discusses four ways in which the industrial can plan its power and steam supply. These include: (*a*) Complete plant, with suitable reserve, no utility connection, (*b*) normal-load plant, no reserve, public utility for excess power and reserve, (*c*) public-utility high-pressure plant, supplying steam and power to the industrial and furnishing excess power to its own lines, and (*d*) purchase all power, and operate a low-pressure industrial steam plant.

Calculations on a number of plant performances for design purposes show that within reasonable accuracy the total operating costs vary as the 0.76 power of the kilowatt-hour output. With this rule of variation it is easy to interpret costs for other load factors.

RECENT INSTANCES OF EMBRITTLEMENT IN STEAM BOILERS. By Frederick G. Straub. [Paper No. FSP-52-39]

The author discusses briefly the cause of the recent boiler explosion at Crossett, Arkansas, attributing the failure to embrittlement produced as a result of using soda-ash treatment on a water too low in sulphate content. Other instances of cracking of seams in steam boilers are also described. Emphasis is placed upon the regular inspection of leaky seams in steam boilers, particularly when the boiler water does not meet the A.S.M.E. recommendation.

AN APPARATUS FOR THE DETERMINATION OF CREEP AT ELEVATED TEMPERATURES. By A. E. White, C. L. Clark, and L. Thomassen. [Paper No. FSP-52-40]

This paper describes an apparatus designed for the purpose of measuring creep of metals at elevated temperatures. Due to the slight changes in dimensions encountered, such an apparatus must be sensitive to small variations. This particular machine is capable of measuring variations in length of the test specimen to about 2.8 millionths of an inch per inch.

The three essential parts of a creep-measuring apparatus are listed as (1) a means of applying and maintaining a constant load, (2) a means of obtaining and maintaining constant a given temperature, and (3) a means of accurately determining any deformation produced in the test piece. The manner in which this machine fulfils each of these conditions is described.

ECONOMICS OF HEAT TRANSFER. By W. J. Wohlenberg. [Paper No. FSP-52-41]

There is a set of proportions ideal for the operation of every manufacturing structure, the discovery of which is predicated upon ascertaining what may be called the economic units into which any structure may be divided. A statement of the cost of operation of an economic unit is here called the economic factor. Such factors assume, depending on their form, either maximum or minimum values for the ideal set of proportions. It is shown how an attack from this point of view may be employed in an attempt to evaluate ideal proportions for the heat-absorbing surface of a steam generator.

EFFECT OF AIR AND TURBULENCE ON CONDENSER-TUBE DETERIORATION. Progress Report No. 3 of the A.S.M.E. Special Research Committee on Condenser Tubes, Comprising the 1929 Report of Its Sub-Committee on Questionnaire. [Paper No. FSP-52-42]

During the past year the Sub-Committee has been engaged in an intensive study to devise means of determining the quantities of air and the degree of turbulence within the condenser water boxes and tubes, and correlating the results with tube deterioration. The work so far has been carried out in the Hudson Avenue and the Gold Street stations of the Brooklyn Edison Company, supplemented by laboratory experiments at Hudson Avenue. The methods used are illustrated in the diagrams and photographs included in this report.

MACHINE SHOP PRACTICE PAPERS

QUALITY CONTROL AND PRODUCTION GAGES. By Earle Buckingham. [Paper No. MSP-52-5]

In this paper the author discusses basic principles entering into quality control and the use of production gages. The development of interchangeable manufacturing has many advantages and should result in economies. Considerable progress has been made by many large manufacturers. Tolerances should be as large as will result in satisfactory operation. The drawings and specifications should give tolerances. The author analyzes of data received from manufacturers regarding cost of inspection and percentage of scrapped parts.

TURNING WITH SHALLOW CUTS AT HIGH SPEEDS. By H. J. French and T. G. Digges. [Paper No. MSP-52-6]

In this paper a method is described for testing lathe tools under shallow cuts and fine feeds. The relations are determined between the cutting speed, feed, depth of cut, and tool life for carbon and high-speed tool steels. Comparisons are made of tools of different forms and of tool life when cutting dry and with water or lard oil. Heat treatment and chemical composition of the tools are also studied, including, in the case of high-speed tool steels, the effects of cobalt, nickel, molybdenum, arsenic, antimony, phosphorus, sulphur, copper, tin, aluminum, titanium, and tantalum. The results obtained under shallow cuts and fine feeds with these steels are compared with those obtained under heavy duty.

A STUDY OF TIN-BASE BEARING METALS—II. By G. B. Karelitz and O. W. Ellis. [Paper No. MSP-52-7]

This paper is a continuation of one presented by the authors at the Pittsburgh Meeting of the A.S.M.E. in 1928, and deals with the mechanism of wiping of babbitt linings, with certan phenomena observed during the casting of tin-base alloys, and with the effects of cold work on them. It is shown that wiping of babbitts is a result of the upper layer of the lining's reaching the solidus temperature.

when the constituent with the lowest melting temperature liquefies, the babbitt becomes "mushy," and is therefore wiped by the journal. The appearance of the castings of various chemical compositions is discussed, and the variation in hardness and microstructure due to cold work is given.

PRESENT PRACTICE IN THE USE OF CUTTING FLUIDS. Progress Report No. 2 of the Sub-Committee on Cutting Fluids of the A.S.M.E. Special Research Committee on Cutting of Metals. Compiled by S. A. McKee. [Paper No. MSP-52-8]

This report is an attempt to indicate, in so far as its scope will permit, either the trend or lack of trend, as the case may be, toward the use of a particular type of cutting agent for a given machining operation on a given kind of metal. It is based on information obtained from sixty-eight of the large users of cutting fluids in this country. Nine tables are presented. The first of these is a general summary. It lists the number of plants using any of three general types of cutting agent (dry, water or emulsions, oils or oil mixtures) for each of nineteen machining operations on eight kinds of metals. Each of the remaining eight tables gives more detailed information pertaining to the cutting agents used for the various operations on a given metal.

ECONOMIES WHICH MAY BE EFFECTED IN POWER TRANSMISSION. By W. W. Nichols. [Paper No. MSP-52-9]

From an economical standpoint of maintenance, power-transmission equipment is not given careful consideration by management. It should not be left to the supervision of some old-time millwright. Belting is not given a close enough inspection upon its receipt to determine if it meets all the requirements laid down by the specifications for its purchase. Many machines upon production work are overbelted, and little attention is given to the correct determination of the size of belt necessary for the work. Heavier belts could be installed profitably. By this means unnecessary wear and tear upon countershaft clutches would be eliminated. More attention should be given to the application of the correct size of motor to individually motor-driven machine tools. Great loss and low power factor result from the methods now pursued. The question of group driving and the economies effected thereby are deserving of being more closely considered and of having their cost compared with individually motor-driven tools, both from an initial and a maintenance standpoint.

TEST CODE FOR HIGH-SPEED STEEL FOR TURNING TOOLS. Report of Sub-Committee "D" on Properties of Materials of the A.S.M.E. Special Research Committee on Cutting of Metals. [Paper No. MSP-52-10]

A review of the applications of tool steels by the Committee resulted in the selection of high-speed tool steel as the subject for the first test code. Other test codes can be developed as soon as the essential characteristics of the high-speed tool-steel test code have been definitely determined. The type of test code will depend upon whether or not the tests are to be conducted in accordance with laboratory procedure or in accordance with the usual facilities available in a machine shop. A tentative test code has therefore been prepared to permit the omission of some of the test apparatus, and the test computations can be reduced to those required by the experimenter.

RAILROAD PAPERS

HIGH-PRESSURE AND HIGH-TEMPERATURE STEAM FOR LOCOMOTIVES. By C. F. Hirshfeld. [Paper No. RR-52-6]

The author states his position as that of giving to railroad men the benefit of experience had in stationary steam-power-plant practice and not as that of telling them what to do in locomotive practice. The advantages of high pressures and temperatures in stationary practice are considered separately for condensing operation and for back-pressure operation, respectively, and the differences are stressed. Certain experiences and observations regarding the behavior of metals and the boiler circulation under extreme conditions are given, and these are followed by speculations regarding the possible lines of development of locomotives.

ALLOY STEELS IN THE RAILROAD FIELD. By Charles McKnight. [Paper No. RR-52-7]

There is increased interest in the use of alloy steels by railroads. They are used purely as a matter of economics. Better work must be done at the same cost or the same work at less cost. The use of alloy steel castings materially cuts down weight, with the same strength and same cost as carbon-steel castings. There are three ranges of steels: Carbon steels are used for the vast majority of railroad purposes, with alloy steels for special applications, and semi-alloy steels, which are slightly more expensive than carbon steels and with slightly better properties, as a compromise. Some of their uses include boiler materials, forgings, and castings. Corrosion-resisting materials, nitriding, and miscellaneous metals are discussed, and the economics of operation are given.

THE STUG SYSTEM OF PULVERIZED-FUEL FIRING ON LOCOMOTIVES. By R. Roosen. [Paper No. RR-52-8]

The object of the system described in this paper is to solve the problem of firing locomotives with coal dust of any description. The author tells of the advantages that can reasonably be expected from the use of such a system, and of some of the difficulties that make pulverized-fuel firing for locomotives a severe problem.

RESEARCH RELATING TO THE ACTION OF 4-WHEEL FREIGHT-CAR TRUCKS. By T. H. Symington. [Paper No. RR-52-9]

This paper includes a study of operating and maintenance problems of car trucks that have resulted from increased weights, greater rigidity, and high speeds. The author discusses the 4-wheel truck as a whole, and includes such features of design as cross-equalization, swiveling resistance, self-squaring, car roll and nosing, guard-rail shocks, lateral motion, and four-point suspension.

Harmonic truck-spring action is discussed at considerable length. It is felt that excessive harmonic spring oscillation at critical train speeds may be caused by eccentricity of wheels.

NOTE: Those who have not registered in the A.S.M.E. Fuels and Steam Power, Machine Shop Practice, and Railroad Divisions whose papers are abstracted on this and the previous pages, and who desire copies of any of these papers, may obtain them by using the form given below.

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AERODYNAMICS

New Phenomenon in. Experimental Results Relating to New Phenomenon in Aerodynamics (Risultati sperimentali relativi ad un nuovo fenomeno di aerodinamica), G. A. E. Raimondi. Notiziario Tecnio di Aeronautica (Rome), vol. 6, no. 10, Oct. 1930, pp. 1–17, 33 figs. Graph illustrates results of experiments showing that two parallel surfaces are attracted to each other if one of them is displaced rapidly parallel to other; sketches illustrate setup of tests with various rotor arrangements.

AIRPLANE ENGINES

Diesel. Heavy-Oil Engines for Aircraft (Les moteurs à huile lourde dans l'aéronautique), E. Marcotte. Revue des Combustibles Liquides (Paris), no. 79 (Supp.), 29 pp., 31 figs. Review of principles of design and thermodynamics, characteristics of fuel; major specifications and constructional details of principal makes, including Clerget, Packard, Sunbeam-Coatalen, Junkers, Maybach, and Fiat.

See also DIESEL ENGINES, Automotive.

Heavy-Oil. The Origin and Development of Heavy-Oil Aero Engines, D. R. Pye. Engineer (Lond.), vol. 150, no. 3911, Dec. 26, 1930, pp. 705–706. It is airship which stands to benefit most by successful development of heavy-oil engine; although airship is at present itself an experiment, from point of view of heavy-oil engine it might be of enormous value as laboratory; by compressing air only and so eliminating preignition, heavy-oil engine is able to use much higher compression and expansion ratio, with consequent higher economy; cycles and modes of operation employed; future progress. Paper read before Roy. Aeronautical Soc., Dec. 11, 1930.

AIRPLANES

Ailerons. The Pearson Rotary Aileron. Aircraft Eng. (Lond.), vol. 2, no. 19, Sept. 1930, p. 226, 3 figs.; see also Aviation Eng., vol. 3, no. 12, Dec. 1930, pp. 7 and 23, 3 figs. Beyond each wing tip is fitted approximately horizontal disk, fraction of chord in diameter, which can be oriented by pilot about its central vertical spindle pivoting in bracket attached as extension to front spar; results of laboratory and flying test.

Autogiros. See AUTOGIROS.

Helicopters. See HELICOPTERS.

Landing Gears. Landing Gears for Airplanes (Sui carrelli per aeroplani), S. Maiorca. Aerotecnica (Rome), vol. 10, no. 9–10, Sept.-Oct. 1930, pp. 689–699, 16 figs. Review of design and functioning of principal types of landing gear, with particular regard to wheel, axle, and shock-absorber arrangement; tables give data on Italian practice; sketches illustrate various types of brakes. Bibliography.

Light Alloys for. Structural and Engineering Light Alloys for Aircraft, R. L. Templin, F. V. Hartman, and E. C. Hartmann. Am. Soc. Testing Matls.—Proc., part 2, 1930, pp. 34–40 and (discussion), 171–214. Paper deals with wrought and cast alloys of aluminum and magnesium which are best suited to aircraft work; their advantages in general field of aircraft construction are briefly discussed; designation of various alloys available is indicated and forms in which alloys are produced commercially are given; tables of data are given on nominal composition, heat treatment, and mechanical properties.

Noise Elimination. Reduction of Airplane Noise. U. S. Dept. Commerce—Aeronautics Bul., no. 25, Oct. 1, 1930, 21 pp., 4 figs. Résumé of research work conducted by aeronautic branch of Dept. of Commerce at Bureau of Standards dealing with methods of measuring sound, propeller noise, engine noise and muffling, and soundproofing the cabin, etc.

Performance Testing. Comparative Performance Tests on Different Airplane Models (Vergleichende Flugleistungsmessungen mit verschiedenen Flugzeugmustern), W. Pleines. Jahrbuch 1930, der Deutschen Versuchsanstalt fuer Luftfahrt, E. V. (Berlin), 1930, pp. 623–637, 25 figs. Method for determining principal performance characteristics are outlined, together with details of mechanical equipment; interpretation of results by graph and tables.

Propeller Vibrations. Resonance Vibration of Air Screws (Resonanzschwingungen von Luftschrauben), F. Liebers. Luftfahrtforschung (Munich), vol. 7, no. 3, May 16, 1930, pp. 137–152, 14 figs.; see also Jahrbuch 1930 der Deutschen Versuchsanstalt fuer Luftfahrt, E. V. (Berlin), pp. 79–94, 14 figs. Mathematical investigation of principal types of vibrations with particular regard to torsional and bending frequencies caused by uneven loading of blades; methods of controlling vibration.

Riveting Methods. Riveting in Metal Airplane Construction (Nietverfahren im Metallflugzeugbau), W. Pleines. Luftfahrtforschung (Munich), vol. 7, no. 1, Apr. 30, 1930, 72 pp., 144 figs.; see also Nat. Advisory Committee Aeronautics—Tech. Memo., nos. 596, 597, and 598, Dec. 1930, pt. 1, pt. 2, 50 pp., pt. 3, 28 pp., 49 figs. Riveting methods and riveting equipment in German metal construction of airplanes with particular regard to practice of Junkers works; strength of riveted joints in duralumin; method of treatment and tensile strength specifications for dural rivets; test arrangement and test data; graph and sketches illustrate joints, stress distribution, and effects.

Spinning Characteristics. Minimum Speed of Airplane and Loss of Speed (La velocita minima dell'aeroplano e la perdita di velocita), A. Eula. Rivista Aeronautic (Rome), vol. 10, no. 11, Nov., 1930, pp. 237–280, 41 figs. Effect of speed on various factors of airplane performance is illustrated by graphs; mathematical investigation of different types of spins and forces acting on plane.

Tailless. The Soldenhof Tailless Plane. Flight (Lond.), vol. 22, no. 1148, Dec. 26, 1930, pp. 1478, 3 figs. Data on Swiss light plane two-seater fitted with 40-hp. Salmson radial air-cooled engine; tare weight 528 lb. and gross weight 990 lb.

ALLOYS

Bronze. See BRONZE.

Copper. See COPPER-NICKEL ALLOYS.

Light. See AIRPLANES, Light Alloys for.

Magnesium. See MAGNESIUM ALLOYS.

ALUMINUM

Sheet. Aluminum Sheet Production, R. J. Anderson. Metallurgia (Manchester), vol. 2, nos. 11 and 12, Sept. 1930, pp. 173–176, Oct., pp. 211–214, vol. 3, nos. 13 and 14, Nov., pp. 4–8, and Dec., pp. 53–56, 7 figs. Sept.: Compositions used for sheet rolling; kinds and grades of sheet. Oct.: Sizes, gages, and tolerances; sheet tempers; heat-treated alloy sheet. Nov.: Raw materials for melting. Dec.: Furnaces for use in melting aluminum and its alloys prior to pouring rolling ingots. Bibliography.

AMMONIA

Properties of. A Study of the Density, Surface Tension, and Adsorption in the Water-Ammonia System at 20 deg., J. H. King, J. L. Hall, and G. C. Ware. Am. Chem. Soc.—Jl., vol. 52, no. 12, Dec. 1930, pp. 5128–5135, 3 figs. Investigation of surface tension of water-ammonia mixtures as compared with theoretical values for ideal mixtures obtained by Whatmough's rule; method for determining density of solutions.

ARTILLERY

Manufacture. Technique in Manufacturing of Modern Artillery Equipment (La technique de réalisation de matériels modernes d'artillerie), Revue Industrielle (Paris), vol. 60, no. 2255, Oct. 1930, pp. 613–619, 14 figs. Historical developments; various characteristics and their realization in modern artillery and associate equipment.

AUTOGIROS

Rigid Construction. Lateral Moments of Self-Rotating Screw of Rigid Construction (Considerazioni sul momento laterale de un'elica autorotante di costruzione rigida), G. Serragli. Aerotecnica (Rome), vol. 10, no. 3, Mar. 1930, pp. 149–162, 5 figs. Mathematical analysis of forces shows possibility of correcting tilting moments with rigid windmill design; characteristics of airscrew with high angle of incidence.

AUTOMOBILE ENGINES

Fuel Economy. Fuel Economizers (Ein aktuelles Thema: Brennstoff-Sparer), H. Rohrbach. Deutsche Motor-Zeit. (Dresden), vol. 7,

no. 11, Nov. 1930, pp. 528, 530, and 532, 2 figs. Possibilities of improving fuel economy by injection of steam into mixture; test results, illustrated by graph, show that addition of oil and water-vapor obtained from crankcase and radiator give fuel economy up to 21 per cent, it always being understood that engine is operating at proper temperature.

AUTOMOTIVE FUELS

Alcohol. Experiences With Alcohol Fuels in Sweden (Ueber Erfahrungen mit Spirituskraftstoffen in Schweden), E. Hubendick. Petroleum (Berlin), vol. 26, no. 50, Dec. 10, 1930 (supp.), pp. 3–9, 4 figs. History of development; experiences with alcohol mixtures; for conditions in Sweden fuel is required which contains no more than 20 to 25 per cent alcohol; properties and advantages of alcohol fuel.

B

BALANCING MACHINES

Types. The Balancing of Machinery, C. N. Fletcher. Mech. World (Manchester), vol. 68, nos. 2292 and 2295, Dec. 5, 1930, pp. 538–539, and Dec. 26, pp. 607–609, 2 figs. Dec. 5: Hofmann-Kunze universal balancing machine. Dec. 26: Hofmann-Kunze high-production balancing machine.

BEARINGS, ROLLER

Heavy-Duty. Mounting Heavy Duty Roller Bearings, S. M. Weckstein. Machine Design, vol. 2, no. 12, Dec. 1930, pp. 34–38 and 70, 9 figs. Sketches illustrate mounting principles for Timken tapered roller bearings as applied to steel-mill roll neck, rolls of rubber refiner; thrust bearings and bearings for vertical shaft.

Practice. Blast Furnace Theory and Practice, R. H. Sweetser. Blast Furnace and Steel Plant, vol. 18, no. 12, Dec. 1930, pp. 1824–1826 and 1828, 1 fig. Survey of progress in practice and operation during recent years, particularly regarding blast-furnace capacity, cleaning of blast-furnace gas, movement of hot metal; adoption of three-shift day; merchant blast furnaces. Paper presented before World Eng. Congress, Tokyo.

BOILER FEEDWATER

Treatment. Experiences With Lime-Barite Process (Erfahrungen mit dem Kalk-Baryt-Verfahren), A. Frederking. Waerme (Berlin), vol. 53, no. 50, Dec. 13, 1930, pp. 943–949, 1 fig. Based on results of number of analyses of water-purification plants, effect of additions of lime and barite is shown and limits of softening determined.

Feedwater Treatment for Superpressure Boilers (Zur Speisewasserpflege bei Hoechstdruckkesseln), P. Hermann. Zeit. des Bayerischen Revisions-Vereines (Munich), vol. 34, no. 19, Oct. 15, 1930, pp. 257–259, 6 figs. Results of author's observations on 100-atmos. boiler plant. Conclusion of this article has been postponed to later date to permit further research and possibly some corrections.

BOILERS

Design. Boilers Trend Toward Large Units. Power, vol. 73, no. 1, Jan. 6, 1931, pp. 17–19, 3 figs. Boiler units in two plants have produced over million pounds of steam per hour, superheaters for steam temperatures over 800 deg. are being furnished, and 19 slag-bottom furnaces have been installed during past year; superheaters and resuperheaters; turbine drives for fan; feedwater problems increase.

Flow Studies in Boiler and Furnace Design (Stroemungstechnische Betrachtungen im Feuerungs und Dampfkesselbau), F. Michel. Feuerungstechnik (Leipzig), vol. 17, no. 23–24, Dec. 15, 1930, pp. 233–238, 9 figs. Necessity of taking into consideration flow theories in design of boilers and furnaces; flow phenomena in pulverized-coal and stoker-fired furnaces; gas current in flues; draft loss and heat transmission; flow and heat transfer in cross-current heating surfaces; air and gas ducts.

High-Pressure. Adapting L. P. Boilers for H. P. Generation. Power Engr., vol. 25, no. 296, Nov. 1930, pp. 417–418, 2 figs. Design features of Kroepelin boiler, whereby additional surface providing high-pressure steam can be utilized in conjunction with low-pressure boilers.

Plates—Embrittlement. Caustic Embrittlement, W. S. Coates. Iron and Coal Trades Rev. (Lond.), vol. 121, no. 3276, Dec. 12, 1930, p. 872. Brief review of research in United States, Germany, and elsewhere on peculiar type of boiler failure characterized by development of intercrystalline cracks in riveted sections of boiler drums below water line, leading in some cases to loss of boiler. Abstracts of paper read before Soc. Chem. Industry.

Embrittlement in Boilers, F. G. Straub. Univ. Ill.—Bul., vol. 28, no. 8, Oct. 21, 1930, 128 pp., 46 figs. Purpose of investigation has been to gather data relative to occurrence of this particular type of boiler-plate cracking in order to determine cause of difficulty and to device methods of preventing it.

Plates—Temperature Effect. Strength of Boiler Plates at Elevated Temperatures (Festigkeitseigenschaften von Kesselblechen bei erhoehten Temperaturen), A. Pomp. Stahl und Eisen (Duesseldorf), vol. 50, no. 50, Dec. 11, 1930, pp. 1737–1741, 6 figs. Determination of 0.05, 0.1, and 0.2 limits, as well as tensile strength, expansion, and contraction at 20, 300, 350, 400, 450, and 500 deg. cent. of 12 boiler plates; relation between yield limit at high temperature and tensile strength at room temperature.

Pulverized-Coal-Fired. Pulverized Fuel Firing for Lancashire Boilers. World Power, vol. 14, no. 84, Dec. 1930, pp. 528 and 530, 1 fig. After several years of experimental work on firing Lancashire type of boiler by pulverized fuel, direct firing without any external combustion chamber was adopted by Fraser and Chalmers; restricted combustion space with this type of firing makes very uniform fine grinding and absolute control of coal and air supply to each flue essential, and central pulverized-fuel plant has therefore been adopted by them as standard for Lancashire-boiler work; attention given to solid-injection burner.

Special Boiler for Pulverized-Coal Firing; the Lopulco Steam Generator (Chaudière spéciale pour la chauffe au charbon pulvérisé Le Vaporigène Lopulco), P. Scherer. Revue Industrielle (Paris), vol. 60, no. 2257, Dec. 1930, pp. 739–741, 3 figs. Equipment and its characteristics described in general way; equipment at Hardenberg mine near Duesseldorf, Germany; heated surface 600 sq. m.; a vaporation capacity, 40 tons per hr.; pressure, 21 atm.; superheating, 370 deg. cent.

Steam-Generating Unit. A Standardized Steam Generating Unit, W. J. Vogel. Combustion, vol. 2, no. 5, Nov. 1930, pp. 31–34 and 55, 3 figs. Standardized type of steam-generating unit which is now available in range of sizes providing capacities from 150,000 to 400,000 lb. of steam per hr.; description of unit being installed in important industrial plant.

Tubes—Stresses in. Stresses in Boiler and Superheater Tubes (Beanspruchung von Siede- und Ueberhitzerrohren), A. Konejung. Waerme (Berlin), vol. 53, no. 48, Nov. 29, 1930, pp. 891–895, 5 figs. Calculation of absolute normal stresses under assumption of complete elasticity; proof is given that heat stresses, contrary to former theory, are not dependent upon maximum heat load of pipe circumference, but on mean heat load; influence of boiler scale; non-elastic behavior of tube material.

Tubes—Testing. Experimental Study of "Ring Test" for Boiler Tubes (Studienversuche ueber die "Ringprobe" fuer Kesselrohre), M. Ulrich. Zeit. des Bayerischen Revisions-Vereins (Munich), vol. 34, nos. 22 and 23, Nov. 30, 1930, pp. 295–299, and Dec. 15, pp. 312–317, 37 figs. on supp. plates. Test was proposed by Koch and accepted by Federation of Large Boiler Owners in their rules for materials and construction of high-pressure boilers; results of recent tests; cause of widening of ring specimens up to 100 per cent in acceptance tests.

Waste-Heat. Exhaust Gas Boilers for Internal Combustion Engines, D. Brownlie. Combustion, vol. 2, no. 5, Nov. 1930, pp. 40–43, 4 figs. Describes several types of boilers which have been specially designed for this service, and gives information on economic and other advantages of such installations.

Water-Tube. Tube Materials for High-Pressure Water-Tube Boilers, S. F. Dorey. Metallurgia (Manchester), vol. 3, no. 13, Nov. 1930, pp. 31–34. Success of high-pressure water-tube boiler is dependent on quality of material used for tubes, for which alloy steels are considered to be more suitable than mild steel; materials for tubes; tubes in service. Bibliography.

Vertical Sectional Water-Tube Boiler. Engineering (Lond.), vol. 130, no. 3387, Dec. 12, 1930, p. 739, 5 figs. Boiler, built by Fraser and Fraser, Lond., is rectangular, and consists of firebrick-lined furnace across which is set inclined nest of water tubes; upper part is cylindrical drum with central uptake, and is connected to headers of tube nest by curved pipes; feedwater is introduced in drum just below water level, and cold water descends by way of downtake pipe connected to bottom header.

BRONZE

Castings. Structure and Mechanical Properties of Bronze Castings (Der Aufbau und die mechanischen Eigenschaften von Gussteilen aus Bronze and Rotguss), Schmid. Metallboerse (Berlin), vol. 20, no. 100, Dec. 13, 1930, pp. 2733–2734. Based on diagram of copper-zinc alloys, phenomena occurring with slow and rapid cooling and resulting structure are shown; influence of metallic and non-metallic admixtures; mechanical properties in relation to tin content.

Nickel Additions. The Effect of Additions of Small Percentages of Nickel to a Copper Tin Bronze, C. Upthegrove, G. Wilson, and F. N. Rhines. Am. Soc. Testing Matls.—Proc., vol. 30, pt. 2, June 23–27, 1930, pp. 512–519 and (discussion), 520–521, 5 figs. Results of laboratory study; substitution of small percentages of nickel for copper results in marked changes in microstructure, 1 per cent causing disappearance of alpha of eutectoid and appearance of dispersed constituent in alpha matrix; in cast alloys annealed for 120 hr. at 800 deg. cent., substitution of nickel for copper results in continuous increase in hardness for alpha constituent, while in constituent corresponding to delta decrease in hardness followed by increase is found.

C

CABLEWAYS

Bi-Cable System. A Ropeway Plant at a Large Oil Works. Engineer (Lond.), vol. 150, no. 3911, Dec. 26, 1930, pp. 696–699, 18 figs. partly on p. 708. Series of ropeways of bi-cable system were installed by R. White and Sons for Agwi Petroleum Corp. of Fawley, Hants, for conveying drums and barrels of asphalt from filling station and loading them into steamers; first is called Land Ropeway, second, Connecting Ropeway and third section, Sea Ropeway.

CAR WHEELS

Stresses in. Contact Pressures and Stress Distributions in Cams, Rollers, and Wheels, E. G. Coker and R. Levi. Instn. Mech. Engrs.—Proc. (Lond.), no. 3, 1930, pp. 693–730, 26 figs. Survey of stress distribution in railway wheels due to methods of construction to be applied to cases such as those of driving wheels of locomotives where crank webs and balancing masses introduce further complications; it also indicates that additional stresses due to use can probably be determined in same manner to fair degree of accuracy.

CARS

Refrigerator. Low Temperature Railway Refrigeration. Cold Storage (Lond.), vol. 33, no. 393, Dec. 18, 1930, p. 367, 2 figs. Brief discussion of Altek system of car refrigeration; trial runs throughout Europe.

CARTRIDGE CASES

Manufacture. The Manufacture of S. A. A. Cartridge Cases, F. Adcock. Engineer (Lond.), vol. 150, nos. 3910 and 3911, Dec. 19, 1930, pp. 668–669, and Dec. 26, pp. 700–702, 20 figs. Article is divided into three parts, first part dealing with production of strip, second with production of cups, and third with remaining operations; in operations of blanking and cupping, British and Continental methods are at variance; both are described, effects of contour of cupping die on base thickness, etc., of cups produced; rules for determination of necessary strip thickness and dimensions of tools to make cups to given specification.

CASE-HARDENING

Accurate. Accurate Case-Hardening. H. Swain. Metallurgia (Manchester), vol. 2, no. 11, Sept. 1930, pp. 185–186. Close study of process of case-hardening will lead to more accurate results; more care may involve greater cost, but there are economic compensations; efficient furnaces; carburizing compound; boxes and methods of packing; re-heating and tempering.

CAST IRON

Corrosion-Resisting. A Heat- and Corrosion-Resisting Cast Iron. Foundry Trade Jl. (Lond.), vol. 43, no. 747, Dec. 11, 1930, p. 403, 1 fig. Data on physical properties of cast iron consisting of about 75 per cent ordinary cast iron, 4 per cent chromium, and balance Monel metal; this composite alloy is known as "nimol;" data on resistance to heat, acid, and atmospheric corrosion.

High-Test. High-Test Cast Iron. Metallurgia (Manchester), vol. 3, no. 13, Nov. 1930, pp. 15–16. Rocking type of electric furnace is claimed to have opened new field for producing uniformly good high-test cast iron without use of expensive alloying elements; round-table discussion on application of Detroit rocking electric

furnace to production of high-duty gray iron.

Machinability. Machinability of Cast Iron in Turning Process (Die Zerspanbarkeit des Gusseisens im Drehvorgang), A. Wallichs and H. Dabringhaus. Giesserei (Duesseldorf), vol. 17, nos. 49 and 50, Dec. 5, 1930, pp. 1169–1177 and Dec. 12, pp. 1197–1201, 36 figs. Curves showing machinability of 19 different groups of cast iron with strength of from 12 to 25 kg. per sq. mm.; machinability is dependent upon Brinell and Rockwell hardness; diagram is developed with which it is possible to determine from Brinell-hardness cutting speed per hour for all cross-sections; comparison of machinability of cast iron, steel, and steel castings.

Nickel and Chromium in. Influence of Nickel and Chromium on Properties of Cast Iron (Influence du nickel et du chrome sur les propriétés de la fonte malléable), L. Thiery. Académie des Sciences—Comptes Rendus (Paris), vol. 191, no. 1, July 7, 1930, pp. 47–49; see also brief translated abstract in Chem. and Industry (Lond.), vol. 49, no. 47, Nov. 21, 1930, p. 1068. Influence on transition temperature of cast iron; replacement of silicon by nickel yields fine graphite more highly disseminated throughout metal; nickel and chromium when simultaneously present give rise to even finer structure.

Temperature Measurements. Temperature Measurements on Molten Cast Iron (Temperaturmessungen an fluessigem Gusseisen), Moeller. Dinglers Polytechnisches Jl. (Berlin), vol. 345, no. 11, Nov. 1930, pp. 206–209, 4 figs. Measuring range from 1250 to 1550 cent.; description of optic pyrometer "Pyropto" developed by Hartmann & Braun, for purpose.

CHIMNEYS

Wind Pressure on. Wind Pressure on Circular Cylinders and Chimneys, H. L. Dryden and G. C. Hill. U. S. Bur. Standards—Jl. Research, vol. 5, no. 3, Sept. 1930, pp. 652–671, 12 figs. Summary of published model experiments on wind pressure on cylinders and of some previously unpublished experiments made at U. S. Bureau of Standard on models, on large cylinder in natural winds, and on power-plant chimney in natural winds; this information is collected and analyzed for purpose of estimating wind pressure on chimneys and other cylindrical structures at known wind speeds.

CONVEYORS

Overhead. Using Ceiling Space through Overhead Conveyor Systems, E. J. Tournier. South Power Jl., vol. 48, no. 12, Dec. 1930, pp. 83–86, 4 figs. Uses and selection of overhead chain conveyors; power required for overhead conveyors; hp. table of monorail conveyors 100 ft. long, running at 10 f.p.m.

COPPER

Extrusion of. Extrusion of Copper and Copper Alloys and Properties of Extruded Rods, P. Siebe. Metal Industry (Lond.), vol. 37, nos. 25 and 26, Dec. 19, 1930, pp. 577–580, and Dec. 26, pp. 605–607, 15 figs. Hot extrusion consists in hydraulic pressing of heated metal billets through a die; there is necessarily difference between properties of front and rear ends of extruded rods owing to fact that amount of working that metal receives becomes progressively greater as billet is extruded; flow lines in billets partially extruded and experiments for avoiding extrusion defects.

COPPER-NICKEL ALLOYS

Properties. Bronzes and Brasses Containing Nickel as Engineering Material (Nickelhaltige Bronzen und Messinge als Werkstoffe in der Metalltechnik). Metallboerse (Berlin), vol. 20, nos. 96 and 98, Nov. 29, 1930, pp. 2636–2637, and Dec. 6, p. 2685. Nickel and nickel alloys; properties of nickel-copper alloys; special bronzes and brasses containing nickel; German silver.

CUPOLAS

Blowing. The Constant-air-weight Method of Cupola Blowing, H. V. Crawford. Iron and Steel Engr., vol. 7, no. 12, Dec. 1930, pp. 559–565, 4 figs. Fundamental requirements of iron melting in cupolas are illustrated by review of chemical reactions; tables and graphs give data on materials entering into cupola during charging and melting process; changes in volume of air under different conditions of atmospheric temperature and pressure; pounds of air per minute per ton of iron melted per hour; comparison of volume and weight methods.

CUTTING TOOLS

Tungsten Carbide. Cutting Pressures and Power Consumption of Widia Tools. Engineer (Lond.), vol. 150, no. 3911, Dec. 26, 1930, pp. 699–700, 3 figs. Mechanism of failure, in author's experience of carbide tools is by dulling of edge and not by wearing forward of cavity in top face, as experienced with steel tools; there are grounds for expecting considerable reductions in power consumption when cutting with new material; at present time it appears reasonable to take approximate figure of half pressure for same cut when tungsten-carbide tools are used in place of high-speed steel tools.

The Future of Tungsten Carbide, W. H. McCoy. Soc. Automotive Engrs.—Jl., vol. 28, no. 1, Jan. 1931, pp. 101–106, 1 fig. Discussion of Production Meeting Paper, indexed in Engineering Index 1930, from issue of Nov. 1930, and Steel, Oct. 16; tabulation of recommended cutting-angles for tools to be used in different materials and describing four varieties of tungsten carbide; examples in which great savings have been made because of infrequent need of tool grinding; large-quantity production jobs and milling operations offer greatest chances for saving.

D

DIE CASTING

Progress in. Progress of Die-Casting Industry, M. Stern. Am. Foundrymen's Assn.—Trans., vol. 1, no. 12, Dec. 1930, pp. 723–733 and (discussion) 733–736, 3 figs. Die casting and its relation to slush casting, permanent-mold casting, centrifugal casting, and pressed casting; importance of gating, venting, and water cooling; air and plunger types of casting machines are illustrated; automatic casting machine capable of producing complicated die castings at rate of over seven operations per minute.

DIES

Forming and Bending. Dies for Bulldozing and Upsetting, G. A. Smart. Heat Treating and Forging, vol. 16, no. 12, Dec. 1930, pp. 1541–1543, and 1554, 8 figs. Sketches illustrate design and principles of combination dies in which several operations such as shearing, punching, and bending are performed simultaneously or progressively.

Designing Dies for Difficult Cup-forming. Machy. (Lond.), vol. 37, no. 947, Dec. 4, 1930, pp. 297–299, 4 figs. Press operations on oil cups, and use of coning dies which increase thickness of walls at certain points; sketches illustrate important points in design of drawing and coning dies; determination of blank diameter.

DIESEL ENGINES

Airless-Injection. The Lister Airless-Injection Engine. Engineering (Lond.), vol. 130, no. 3389, Dec. 26, 1930, pp. 802–804, 9 figs. Engine operates on dual-chamber system in which starting difficulty is ingeniously overcome by varying compression; it will start quite easily by hand in coldest weather, on any ordinary Diesel oil, while running is at all times as smooth as that of good gasoline engine.

Automotive. Light Weight Diesel Engines (Leichtgewichts-Dieselmotoren) A. E. Thiemann. Automobiltechnische Zeit. (Berlin), vol. 33, no. 35, Dec. 20, 1930, pp. 841–845. Review of progress in design with tables giving principal construction and performance data of outstanding international makes, including marine and aircraft engines.

High-Speed. Fiat High-Speed Diesel Engine. Power Engr. (Lond.), vol. 25, no. 297, Dec. 1930, pp. 456–457, 2 figs. Design and construction of features of new Italian airless-injection engine of 10 b.hp. per cylinder; three-cylinder engine with 120 mm. diameter and 230 mm. stroke, running at 800 r.p.m.

MWM-Benz Stationary and Automotive High-Speed Diesel Engine, L. Hausfelder. Diesel Power, vol. 8, no. 12, Dec. 1930, pp. 626–628, 6 figs. Design, constructional, and operating characteristics of Model RS 27 of Motorenwerke Mannheim, A.G.; four-cycle vertical engine with six or eight-cylinders of 8.07 in. bore, 10.63 stroke, running at from 800 to 1000 r.p.m.; at lower speed six-cylinder unit develops 250 b.hp. and 300 at higher one, its weight being 6170 lb.; side and transverse sectional views; characteristic curves at variable speed.

The New De La Vergne High-Speed Diesel Engine With Dual Valves. Diesel Power, vol. 8, no. 12, Dec. 1930, pp. 622–624, 3 figs. Unit is distinguished by integral, enclosed construction and combustion chamber of open type; 9-in. bore by 11-in. stroke; normal operating speed is 750 r.p.m. at which 300 b.hp., corresponding to 50 b.hp. per cylinder are developed in 6-cylinder unit; low rate of fuel consumption is quoted.

Marine. 1000-H.P. Eight-Cylinder Horizontal Airless-Injection Engine. Engineering (Lond.), vol. 130, no. 3386, Dec. 5 1930, p. 723, 1 fig. Large Crossley-Predier engine, while being suitable for land work, and for large ships auxiliaries, is put forward by makers as being particularly adapted for Diesel-electric propulsion work, where low headroom required would be very advantageous in certain types of vessel; engine operates on 4-stroke cycle; horizontally opposed cylinder arrangement is adopted, with cylinders on each side of crankshaft.

Supercharging. The Turbo-Compressor as Supercharger, J. Holmes. Mech. World (Manchester), vol. 88, nos. 2293 and 2295, Dec. 12, 1930, pp. 551–554 and Dec. 26, pp. 603–606, 9 figs. Graphic and mathematical data; results of experiments on supercharged Diesel engine by Stodola; work done by Rateau; tests carried out in shops of Burmeister and Wain, Copenhagen; concludes that most supercharging systems involve use of fair proportion of main engine output, turbo-supercharger is capable of increasing engine output to degree far beyond amount that slight back pressure involves. Abstract of paper presented before Instn. Engrs. and Shipbldrs. in Scotland.

Temperature Measurements. Thermometric Control of Diesel Engines (Messtechnische Ueber wachung von Dieselmaschinen), W. Liesegang. Waerme (Berlin), vol. 53, no. 51, Dec. 20, 1930, pp. 966–969, 8 figs. Separation of measuring and recording elements, which is one of advantages of electric measuring methods, is desirable for Diesel practice; temperature measurement with electric resistance thermometers on oil tank; measurement of fuel and lubricating-oil consumption as basis for determining fuel efficiency; Diesel pyrometer for determination of exhaust-gas temperature of each cylinder; exhaust-gas analysis.

Tests. Trials of Crossley-Premier Oil Engine Engineering (Lond.), vol. 130, no. 3387, Dec. 12, 1930, p. 740. Particulars of series of tests on Crossley-Premier horizontal oil engine carried out at Sandi-acse Works of Premier Gsa Engine Co. by W. A. Tookey; engine, which was rated at 750 b.hp., had six cylinders, 18 in. in diam., piston stroke being 8 in., and of solid-injection type.

DIPHENYL

Specific Heat of. The Specific Heat of Diphenyl, H. O. Brugmann and L. W. T. Cummings. Indus. and Eng. Chem., vol. 23, no. 1, Jan. 1931, pp. 37–39, 5 figs. Specific heat of diphenyl has been determined by two independent methods; batch calorimeter was used in range from 77.6 to 196.5 deg. cent. and flow calorimeter from 147.7 to 347.0 deg. cent.; average deviation of experimental points from relation given is less than 2 per cent for both methods.

The Specific Heat of Liquid Diphenyl, R. F. Newton, B. D. Kaura and T. DeVries. Indus. and Eng. Chem., vol. 23, no. 1, Jan. 1931, pp. 35–37, 1 fig. Specific heat of diphenyl was first determined by electric heat input method and by method of mixtures; later as check on these determinations, specific heat was redetermined by another electric heat input method, and by correlating rate of cooling of container of diphenyl with heat input necessary to maintain constant temperature; results reported are believed to be accurate within 1 per cent.

E

ELECTRIC FURNACES

Annealing. Bright-Annealing by the Gruenewald Process, F. W. Mueller. Metallurgia (Manchester), vol. 3, no. 14, Dec. 1930, pp. 69–70, 3 figs. To maintain clean bright surface on annealed metal, precautions against oxidation are necessary, as well as regularity of suitable temperature; features of Gruenewald furnace; method of working; furnace layout; temperature and power regulation graph. Translated from Das "Gruenewald-Blankgluehverfahren," Metallwirstschaft, June 20, 1930.

ELECTRIC WELDING, ARC

Atomic Hydrogen. Welding With Atomic Hydrogen Process, S. Martin, Jr. Welding, vol. 1, no. 14, Dec. 1930, pp. 990–991, and 998, 6 figs. Proper method for welding steel castings, alloy steels, other metals and the repair of dies; pertinent notes on hydrogen.

ELEVATORS, ELECTRIC

Control. Electric Leveling Gear for Lifts. Engineering (Lond.), vol. 130, no. 3387, Dec. 12, 1930, pp. 742–743, 6 figs. Arrangement devised and patented by M. D. Scott, of Marryat and Scott, London, known as "Levelectric," employs two motors, smaller being mounted above larger to economize floor space.

High Car Speeds. Higher Car Speeds Proposed for Elevators. Power, vol. 73, no. 1, Jan. 6, 1931, pp. 30–31, 2 figs. Developments nearing accomplishment are car speeds of 1200 ft. per min., double-deck cars serving two floors at a time, and local and express cars in same hoistway.

F

FLOW OF FLUIDS

Turbulent. Characteristics of Turbulence in Cylindrical Conduits (Sui caratteri della turbolenza nelle condotte cilindriche), N. del Nunzio. Elettrotechnica (Milan), vol. 17, no. 32, Nov. 15, 1930, pp. 730–733, 7 figs. Report on experimental study made at department of applied physics of University of Padova, leading to development of method of measuring frequency and amplitude of eddies naturally forming in streams of gas or water; special instrument was built on principle of hot-wire anemometer combined with oscillograms; study of special phenomena on flow in immediate vicinity of conduit walls.

FLOW OF GASES

Pipes. Tests on Pressure Loss and Calculation of Pipe Lines (Druckverlustversuche und Leitungsberechung), O. Helbing. Roehrenindustrie (Berlin), vol. 23, nos. 25 and 26, Dec. 4, 1930, pp. 379–381 and Dec. 18, pp. 390–392, 2 figs. Methods of calculating flow of gases in pipes and effect of velocity, viscosity, and condition of pipe surface.

FLOW OF LIQUIDS

Pipes. Causes of Velocity of Losses in Pipes (Ursachen der Stroemungsverluste in Rohren), H. Nippert. Roehrenindustrie (Berlin), vol. 23, nos. 25 and 26, Dec. 4, 1930, pp. 377–379 and Dec. 18, p. 389, 8 figs. Methods of calculating losses of pressure and velocity caused by character of flow and conditions of pipe surface.

FLOW OF WATER

Pipe Bends. Loss of Head in Curved Smooth Pipe Lines (Der Druckabfall in gekruemmten glatten Rohrleitungen), H. Richter. Forschungsarbeiten auf dem Gebeite des Ingenieurwesens (Berlin), no. 338, 1930, 30 pp., 34 figs. Report on experimental study made at Freiberg Mining Academy for determining laws of flow of water in glass and drawn copper pipe, 20 to 40 mm. in diam., both straight and curved; pressures were measured to within 1/1000 mm. of water column; loss of head was determined as function of Reynolds' number, angle of deflection, radius of curvature, and diameter of pipe; formula derived was found in agreement with observations.

FOUNDRY SAND

Control. Some Recent Advances in the Field of Foundry Sand Control, A. A. Grubb. Am. Foundrymen's Assn.—Trans., vol. 1, no. 12, Dec. 1930, pp. 34–46, 3 figs. Reasons for sand troubles; effect of grain-size on proportion of cereal binder required to bond steel sand; tables gives data on four sands of same grain fineness but widely different grain distribution; chart of American Foundrymen's Association grading classifications for foundry sands.

G

GEARS

Geneva Stop. Curve-Drive Gears With Continuous Drive (Wenig Beachtete und Wenig Bekannte Kurventrieb-Schaltwerke Mit Kintinuierlichem Antrieb), R. Klaus. Werkstattstechnik (Berlin), vol. 24, no. 23, Dec. 1, 1930, pp. 629–635, 54 figs. Design and kinematics of series of gears derived from Geneva stop.

Hobs for. Determination of Dimension of Hob for Involute Gears (Die Bestimmung der Abmessungen von Stirnradwaelzfraesern fuer Evolventenverzahnungen), B. Windmueller. Maschinenbau (Berlin), vol. 9, no. 24, Dec. 18, 1930, pp. 800–803, 12 figs. Examples illustrate methods of calculating dimensions together with suggestions for standardization; determination of degree of undercutting and shape of cutting edges.

Lubrication. Lead-Base Lubricants and Their Use, J. A. Edwards. Soc. Automotive Engrs.—Jl., vol. 28, no. 1, Jan. 1931, pp. 50–52 and (discussion) 60–65. Physical properties and composition of lead-base gear lubricants with particular regard to lubricating characteristics specifications of three manufacturers of automotive products for lead-soap lubricants.

Power-Transmission. Power Transmission Gearing, E. Gregory. Instn. Mech. Engrs.—Proc. (Lond.), vol. 3, 1930, pp. 751–764, 9 figs. Developments in design and application of four distinct types, namely, speed-reduction gearing speed-increasing gearing, power gearing, speed-change gearing.

GLUE

Properties. Plywood Glues (Ueber Sperrholzleime), O. Gerngross. Jahrbuch 1930 der Deutschen Versuchsanstalt fuer Luftfahrt E. V. (Berlin), 1930, pp. 428–433. Action of glues and requirements of glues for plywood; results of experimental investigation of various glues, including casein, bakelite, yavan, cellulose, etc.

GRINDING MACHINES

Improvements in. Grinding Machines Becoming More Automatic, H. W. Dunbar. Iron Age, vol. 127, no. 1, Jan. 1, 1931, p. 53. Changes in design and operation of grinding equipment with particular regard to automatic and semi-automatic operation.

GRINDING WHEELS

Testing. Grinding Wheels and Their Testing (Schleifscheiben und ihre pruefung), H. Schoenerr. Maschinenbau (Berlin), vol. 9, no. 23, Dec. 4, 1930, pp. 767–771. 2 figs. Difficulties in judging qualities of grinding wheels; sketches illustrate principal features of testing methods and set-up, together with data of two tests with different grinding wheel); relative importance of various factors affecting grinding efficiency of wheels.

H

HELICOPTERS

Stability Calculation. Elements of Stability Calculation for Helicopter (Elements du calcul de stabilité d'un hélicoptère), N. Florine. Service Technique de l'Aeronautique—Bul. (Bruxelles), no. 10, May 1930, pp. 3–50. Mathematical analysis based on theory of stability of small vibration of airplanes; development of formulas for study of airplane with flapping wing); simplified methods for calculating resistances of propeller; application of derived formulas to three types of helicopters with two propellers.

HIGH-SPEED STEEL

Cutting Efficiency. Effect of Heat Treatments on Efficiency of High-Speed Steels, E. Kothny. Iron Age, vol. 126, no. 25, Dec. 18, 1930, pp. 1848–1852, 11 figs. Results of tests show that cutting efficiency of high-speed steels, working on hard and medium-hard steels, can be considerably increased by tempering at 590 deg. cent.; tables give data on appearance of fracture and behavior of turning tools when touched by file; time of turning in hardened and in hardened-tempered condition, depth of cut, 4 mm. feed, 1.5; photomicrograph illustrates crystal structure obtained by various heat treatment.

HYDRAULIC TURBINES

Control. Hydraulic Turbine Governors and Frequency Control. Nat. Elec. Light Assn.—Report, no. 13, Dec. 1930, 32 pp., 39 figs. Fundamental principles underlying design and operation of hydraulic governor; question of frequency control as developed to date; economical distribution of load on various units of system; regulation of impulse wheels and application of frequency control; instability of hydroelectric units as related to governor, etc.

Design. Graphical Calculation of Flow Conditions and Energy Absorption of Given Turbine Rotor (Ueber die graphische Berechnung der Stroemungsverhaeltnisse und der Leistungsaufnahme in einem gegebenen Turbinenrad), F. Weinig. Zeit. fuer Angewandte Mathematik und Mechanik (Berlin), vol. 10, no. 5, Sept.-Oct., 1930, pp. 434–453, 21 figs. Theoretical mathematical analysis.

High-Efficiency. Francis Turbine of High Efficiency (Hoher Wirkungsgrad einer Francisturbine), F. Niethammer. V. D. I. Zeit. (Berlin), vol. 74, no. 49, Dec. 6, 1930, pp. 1665–1666, 4 figs. Construction and tests of spiral turbine, rated 11,000 hp. at 92 m. head, installed at Hohenfurt Hydroelectric plant in Czechoslovakia; maximum efficiency of 95 per cent is indicated.

High-Head. Service Record of Highest-Head Reaction Wheel, E. D. Searing. Power, vol. 72, no. 23, Dec. 2, 1930, pp. 892–894, 4 figs. Five years' service and maintenance experience for 35,000-hp. Francis-type turbine, operating under head that varies from 860 to 930 ft., in Oak Grove plant of Pacific Northeast Public Service Company in Oregon; governor oil-pressure system.

Propeller Type. Generalized Theory and Design of a Propeller Turbine, O. Miyagi. Tohoku Imperial Univ.—Technology Reports (Sendai), vol. 9, no. 3, 1930, pp. 367–376, 4 figs. Forms of inner and outer walls of propeller turbine, between which clearance space opens wide; formulas to determine entrance and exit forms of runner vanes with respect to velocities and angles; moment and power developed by it; graphical solution is explained by which determination of all values relating to runner vanes become extremely simple.

HYDRODYNAMICS

Flow About Body in Compressible Fluid. Flow About a Body in a Compressible Fluid (Stroemung um einen Koerper in einer kompressiblen Fluessigkeit), G. J. Taylor. Zeit. fuer Angewandte Mathematik und Mechanik (Berlin), vol. 10, no. 4, July-Aug., 1930, pp. 334–345, 5 figs. Theoretical mathematical discussion of problem, based on Rayleigh's principle with special reference to circular cylinders and airplane wings; outline of author's mechanical method of solution; empirical criterion for cessation of convergence; determination of limits of maximum velocity in eddyless motion. Paper read before Int. Congress of Eng. Mechanics, at Stockholm.

HYDROELECTRIC POWER PLANTS

Pumped-Storage. Construction of Storage Reservoir and Penstocks of the Bringhausen Pumped-Storage Hydroelectric Plant (Die Bauarbeiten am Speicherbecken und an der Rohrbahn des Speicherkraftwerkes Bringhausen), Walch. Bautechnik (Berlin), vol. 8, no. 49, Nov. 14, 1930, pp. 737–741, 16 figs. Report on methods of construction of concrete gravity dam, about 22 m. maximum height, and of penstock 990 m. long; details of bottom lining of reservoir consisting of 10 cm. layer of concrete, bituminous coating, and superimposed layers of sand and gravel.

Scotland. The Lochaber Water Power Scheme of the British Aluminium Company. Engineering (Lond.), vol. 130, nos. 3385 and 3387, Nov. 28, 1930, pp. 674–676, and Dec. 12, pp. 734–736.17 figs. Nov. 28: Junction of surge chamber and upper end of pipe line is effected through two penstock tunnels, 12 ft. in diam.; valve house consists of 54-in. hydraulically operated isolating sluice valve, 69½-in. automatic self-closing balanced disk valve, and two 18-in. anti-vacuum valves. Dec. 12: Power house is equipped with five main units each comprising 10 000-hp. Pelton wheel driving two generators, which supply d.c. at 300 volts running at 250 r.p.m. (Concluded.)

The Pumped-Storage Hydroelectric Station at Niederwartha, Germany. Elec. Engr. Australia and New Zealand (Melbourne), vol. 7, no. 8, Nov. 15, 1930, pp. 273–277, 6 figs. Station is described to illustrate practical aspects and economy of this system of dealing with peak loading; article makes special reference to 27,000 hp. Voith-Sulzer centrifugal pumps which raise water from lower to upper storage; in this plant single dynamo-electric machines act both as generators and motors, being direct coupled to turbines and to pumps as desired.

I

INDUSTRIAL MANAGEMENT

Cost Accounting. Characteristics of Manufacturing Plants (Die Charakteristik des Betriebes), G. Schlesinger. Werkstattstechnik (Berlin), vol. 24, no. 24, Dec. 15, 1930, pp. 661–664, 14 figs. Interpretation of relation between overhead and manufacturing new graphical method for determining and separating fixed and proportional overhead items; importance of this separation for ability of plant to work at different capacities.

Cost Accounting for Small Series and Unit Production (Fabriksabrechnung der Einzel- und Kleinserienfertigung , J. H. Hazuka. Sparwirtschaft (Vienna), vol. 8, nos. 10 and 11, Oct. 1930, pp. 451–456, and Nov., pp. 499–507. Tables and graphs illustrate principal types of accounting systems for all materials, wages, overhead, and allocation of costs.

Overhead the Cost of Production Preparedness, A. H. Church. Factory and Indus. Mgmt., vol. 81, no. 1, Jan. 1931, pp. 38–41, 3 figs. Overhead considered from standpoint of four efficiencies of production; efficiency of preparedness;

efficiency of utilization; efficiency of processing time; efficiency of direct labor.

The Use of Constants in Figuring Costs, A. Huntington. Iowa Eng. Soc.—Proc., vol. 5, no. 4, Oct. 1930, pp. 9–17. Reference to Alford-Hannum paper on "kiloman-hour" unit; nature and value of constants in cost calculations; examples of cost of generating and distributing power; agricultural production; department store operations; machine operations in manufacturing plant; transportation.

Production Planning. Rationalization in Preparation of Work for Machine Shop (Rationalisierung der Arbeitsvorbereitung fuer die Werkstatt), E. T. Bickel. Maschinenbau (Berlin), vol. 9, no. 23, Dec. 4, 1930, pp. 771–777, 12 figs. Purpose and extent of planning; subdivision and assignment of work according to quality and quantity of operations; blank forms and diagrams illustrate examples of organization and planning.

Productivity. Ratio of Value of Production to Wages and Their Purchasing Power in Manufacturing Establishments, 1848–1929. E. Stewart. Monthly Labor Rev., vol. 31, no. 6, Dec. 1930, pp. 33–36. Study of relative share of wage earners in product of their labor, together with relation between purchasing power of wages paid to labor and value of products of that labor developed from analysis of basic figures as shown by United States census over period of 80 years.

Purchasing. How Much Should One Buy to Get the Lowest Final Cost? H. Kilborn. Iron Age, vol. 126, no. 4, July 24, 1930, pp. 217–220, 1 fig. Use of alignment chart incorporating such variables as quantity used in year (or month), price differentials based on quantity, interest on investment, cost of buying, trend of market price, cost of storage and insurance, probability of deterioration, and possibility of obsolescence.

Science in. Science in Works Management. W. Taylor. Instn. Mech. Engrs.—Proc. (Lond.), no. 3, 1930, pp. 801–814. Principles of economics of importance to mechanical engineers, industrial psychology and physiology; estimating, planning, time setting, sales engineering, quality control, standardization, production control, financial control.

INDUSTRIAL PREPAREDNESS

Educational Orders for Munitions. Educational Orders for Munitions, E. T. Trigg. Army Ordnance, vol. 11, no. 63, Nov.-Dec. 1930, pp. 185–186. Significance of educational orders to adequate national defence; experiences gained from World War.

Industrial Survey. A Method for the Survey of Industry, W. Soderholm. Army Ordnance, vol. 11, no. 63, Nov.-Dec. 1930, pp. 199–204 and (discussion), 204. Proposed improvement in planning for industrial preparedness; scheme encompasses two steps, first the analysis and determination of basic production data, and second, arrangement of this information in form that will enable District personnel to survey and determine available capacity.

Munitions Supply Program. The Control of Industry in War. F. H. Payne. Army Ordnance, vol. 11, no. 63, Nov.-Dec. 1930, pp. 181–182. Principles and procedure of munitions supply program being developed by U. S. War Departments by which industry may promptly begin manufacture of munitions army will need initially in major war, and government may mobilize country's industrial and economic assets into one coordinated team to assist in prosecution of war.

INDUSTRIAL TRUCKS

Storage-Battery. Storage Battery Traction. J. A. Hunt. Instn. Elec. Engrs.—Students' Quarterly Jl. (Lond.), vol. 1, no. 2, Dec. 1930, pp. 74–82, 5 figs. Greatly increased use of storage batteries for truck and vehicle propulsion during last few years is due to striving for more efficient and at same time more economical handling of material; industrial trucks and tractors; types of trucks; economic advantages; energy consumption; comparative advantages of battery truck; battery locomotives for narrow gage and standard gage; battery-oil-electric locomotives. Abstract of paper read before Northwest section Instn. Elec. Engrs., Apr. 8, 1930.

INTERNAL-COMBUSTION ENGINES

Detonation. Theoretical Investigation of Detonation Phenomena in Internal-Combustion Engine (Ricerca teorica sul fenomeno della detonazione nei motori a scoppio), G. Manzella. Notiziario Tecnico di Aeronautica (Rome), vol. 6, no. 8, Aug. 1930, pp. 149–162, 5 figs. Attempt at mathematical calculation of relations between factors controlling combustion, i.e., physical state of burnt and unburnt gases during combustion, flame propagation, formation of pressure wave, etc.

Starting. Starting of Internal-Combustion Engines (Das Anlassen von Verbrennungsmotoren). V.D.I. Zeit. (Berlin), vol. 74, no. 50, Dec. 13, 1930, pp. 1703–1709, 24 figs. Abstract of papers presented at 69th Convention of V.D.I. at Vienna by H. Lang, W. Riehm, G. Jendrassik, C. A. Fieber dealing with starting methods for all types of Diesel engines; investigation by M.A.N. of starting speed of Diesel engine; sketches illustrate fuel injection pumps of Ganz-Jendrassik and Hesselman engines.

[See also AIRPLANE ENGINES; AUTOBILE ENGINES; DIESEL ENGINES; OIL ENGINES.]

IRON AND STEEL PLANTS

Germany. Iron and Steel Plant of Mannesmannroehren-Werke (Huettenwerkanlage der Mannesmannroehren-Werke), P. Stern. V.D.I. Zeit. (Berlin), vol. 74, no. 50, Dec. 13, 1930, pp. 1689–1695, 17 figs. Layout and equipment of divisions Schulz-Knaudt, Huckingen, with particular regard to transportation and materials handling facilities; blast furnace plant with two furnaces of 800 tons each; data on Thomas works with four 30-ton converters, six 50-ton open hearth furnaces, blooming mills and auxiliary equipment.

K

KINEMATICS

Three-Dimensional Motions. Velocity Diagrams of Three-Dimensional Motions (Geschwindigkeitsplaene raeumlicher Getriebe), H. Winter. Zeit. fuer Angewandte Mathematik und Mechanik (Berlin), vol. 10, no. 3, May/June 1930, pp. 274–284, 8 figs. Graphical methods developed by Fruebler, Mueller, and Alt are reviewed and illustrated by examples.

L

LAPPING MACHINES

Output and Limits of. Wear Is Reduced by Machine Lapped Parts, S. Player. Automotive Industries, vol. 63, no. 25, Dec. 20, 1930, pp. 906–908, 5 figs. Principal advantages of machine lapping and important points of lapping technique; data on output and limits of lapping machines in manufacture of automobile engines.

LATHES

High-Speed. Super High-speed Lathe. Engineer (Lond.), vol. 150, no. 3910, Dec. 19, 1930, pp. 684–685, 6 figs. Lathe designed by John Holroyd & Co. to take full advantage of most modern cutting-tool materials, such as tungsten-carbide, etc., is electrically driven and controlled on Ward Leonard system, main 45-hp. variable-speed motor being directly coupled to spindle through one pair of double-helical oil-sprayed gear wheels in headstock.

LOCOMOTIVES

Design. Developments in Steam Locomotives (Die Vervollkommnung der Dampflokomotive), L. Schneider. Zeit. des Bayerischen Revisions Vereins (Munich) vol. 34, nos. 22 and 23, Nov. 30, 1930, pp. 301–303, 3 figs. Nov. 30. Steam-turbine locomotive of J. A. Maffei: high-pressure locomotives of Henschel-Schmidt and Winterthur design. Dec. 15: Loeffler-Schwartzkopff high-pressure locomotive; Kitson Still steam-Diesel locomotive.

Numerical Predetermination of Best Traveling Speed of Reciprocating Superheated-Steam Locomotives of the Single Expansion Type (Ueber die rechnerische Vorausbestimmung der guengstigsten Fahrgeschwindigkeit von Kolbenheifsdampflokomotiven) einstufiger Dampfdehnung), T. Achterberg. Glasers Annalen (Berlin), vol. 107, no. 12, Dec. 15, 1930, pp. 147–151, 1 fig. Determination of actual steam consumption.

Diesel. Diesel Locomotives With Special Regard to Compressed Air Transmission (Ueber Diesellokomotiven mit besonderer beruecksichtigung der Dieseldruckluftlokomotive), J. Gieger. Organ fuer die Fortschritte des Eisenbahnwesens (Berlin), vol. 85, no. 17, Sept. 1, 1930, pp. 379–384, 10 figs. Review of experiences with locomotives using different types of transmission; advantages of compressed air over electric transmissions and geared transmission are illustrated by graphs.

Railway Traction by Oil-Engines, E. L. Chorlton. Instn. Civil Engrs.—Proc., 1929–30, part 1, pp. 197–226 and (discussion) 227–258, 12 figs. Comparison of efficiency with steam locomotives; advantages for railway service; cost of operation; typical equipment.

Direct-Steaming. Direct Steaming Railroad Locomotives From Terminal Power Stations, P. E. Roll. Combustion, vol. 2, no. 6, Dec. 1930, pp. 25–27, 3 figs. Substantial savings are being effected in railroad terminals by using steam from stationary plants to bring locomotives up to working pressure; method is now being used in about 30 engine houses; stationary plants providing this service must be extremely dependable and must be designed to meet fluctuating load demands; in addition to fuel economy and considerable time saving there are number of other advantages.

Electric. Electric Locomotives, D. J. Watkins. Instn. Elec. Engrs.—Jl. (Lond.), vol. 69, no. 408, Dec. 1930, pp. 108–109. Mechanical arrangement of locomotive and electrical gear in so far as it affects mechanical design; influence of mechanical arrangement on riding of locomotive; some of most important driving systems are described and criticized, and short explanation of causes of trouble in side-rod drives is given.

The Development of the Electric Locomotive, E. W. Porter. Instn Elec. Engrs.—Jl. (Lond.), vol. 69, no. 408, Dec. 1930, pp. 65–70. Points in locomotive design that are of radical importance; description of direct drive with armature on axle; street-railroad type geared drive; quill drive with single or twin motor; individual-axle drive incorporating special connection between gear and driving wheels to allow of movement on springs, with whole of motor and gearing spring-borne.

Feedwater Treatment. Water Conditioner Shows Savings on the Milwaukee. Ry. Age, vol. 89, no. 25, Dec. 20, 1930, pp. 1321–1323, 5 figs. Tests indicate average locomotive-feedwater temperature of 208.6 deg. fahr. and oxygen elimination of 82.4 per cent; piping diagram of water conditioner application; feedwater temperature maintained in excess of 140 deg. fahr.; diagram showing construction of type A and type B conditioners as applied to left water leg of tender tank; special design boiler feed pump.

Freight. Chesapeake & Ohio Powerful Locomotives for Coal Handling. Ry. Jl., vol. 36, no. 12, Dec. 1930, pp. 25–28 and 34, 11 figs. Locomotives, which are of 2-10-4 type, are claimed to be most powerful two-cylinder locomotives ever built; cylinders 29 by 34 in.; driving wheels 69 in.; boiler-pressure 260 lb. per sq. in.; total tractive force 106,584 lb.; total engine wheel base 49 ft. 3 in.; total engine weight 566,000 lb.; design and constructional features.

Industrial. Industrial Steam Locomotives. Baldwin Locomotives, vol. 9, no. 3, Jan. 1931, pp. 67–74, 27 figs. Range in type and size required for industrial work shown by brief descriptions of many examples.

Oil-Electric Switching. Witcomb Oil-Electric Switchers on the Milwaukee. Ry. Mech. Engr., vol. 104, no. 12, Dec. 1930, pp. 675–676, and 685, 3 figs. Ninety-ton machines show favorable results in comparison with steam power displaced in heavy industrial switching service; principal dimensions and equipment; service performance on Milwaukee; details of construction; special provision for operation in cold weather.

Passenger. Five 4-6-4 Type Locomotives for the Canadian National. Ry. Mech. Engr., vol. 104, no. 12, Dec. 1930, pp. 693–695, 4 figs.; see also Can. Ry. and Mar. World, no. 394, Dec. 1930, pp. 747–749, 4 figs. Locomotive designed for fast passenger service; special attention given to producing attractive appearance; cylinders 23 by 28 in.; driving wheels 80 in.; boiler pressure 275 lb. per sq. in.; total starting tractive force 53,400 lb.; total engine weight in working order 356,400 lb.; total engine wheelbase 40 ft. 2 in.; list of special equipment applied.

Three-Cylinder. New 4-6-2 Three-Cylinder Locomotives, Central Argentine Railway. Ry. Gaz. (Lond.), vol. 53, no. 22, Nov. 28, 1930, pp. 705–708, 7 figs. Details of Caprotti valve gear for three-cylinder engine; cylinders 19½ by 21 in.; coupled wheels 6 ft. 2½ in.; boiler pressure 25 lb. per sq. in.; tractive force at 85 per cent pressure 38,000 lb.; weight of engine in working order 97 tons; total engine wheel base 35 ft. 1¾ in.

LUBRICANTS

Synthetic. Oilfilm, New Synthetic Lubricant (Oilfilm ein neues kuenstliches Schmiermittel). Petroleum (Berlin), vol. 26, no. 50, Dec. 10, 1930 (supp.), pp. 12–13. New lubricant is substitute for mineral lubricating oils and greases; it is neither mineral, vegetable, nor animal oil, but chemical preparation made according to patent by J. Woudhuysen, by S. A. Lubricating Products, Brussels; applications of lubricant are given and its properties compared with those of mineral-oil lubricants.

Testing. Observations on the Testing of Lubricants, E. Wooler. Soc. Automotive Engrs.—Jl., vol. 28, no. 1, Jan. 1931, pp. 53–60, 15 figs. Design and operation of testing machine to determine load-carrying capacity of lubricants for spiral-bevel and hypoid gears; results with various oils and compounds are shown in charts; coefficients of friction, oil temperatures, maximum load carried at different rubbing speeds; gear-tooth loads as high as 1800 lb. per in. of tooth length.

M

MACHINE SHOPS

Lighting. Lighting the Machine Shop, M. Warren. Modern Machine Shop, vol. 3, no. 7, Dec. 1930, pp. 11–14, 16, 18 and 48, 7 figs. Investigation of plants of various companies show effect of proper lighting on efficiency; graph illustrates relation between voltage and light intensity.

MACHINE TOOLS

Chucks. Chucking and Work Holding, E. W. Field and J. H. Garnett. Machy. (Lond.), vol. 37, nos. 949 and 950, Dec. 18, 1930, pp. 377–383 and Dec. 25, pp. 409–413, 31 figs. Dec. 18: Review of work-holding devices designed to increase production; sketches illustrate automatic bar chuck leaving spindle bore free; diagrams showing effect of cutting torque in hand and power chucks; Forkardt wedge-type air chuck. Dec. 25: Indexing chucking fixtures; mechanically assisted chucks; air-chuck applications. Abstract of paper read before Instn. Production Engrs.

Design. Development Tendencies in Construction of Machine Tools (Utvecklingstendenser Foer Verktygsmaskin-Konstruktionen), M. Kronenberg. Teknisk Tidskrift (Stockholm), vol. 60, no. 51, Dec. 20, 1930 (Mekanik), pp. 160–168, 13 figs. Scientific discussion of operation problems; lighter construction of machines and use of high-speed cutting materials cut operation costs; balancing of speeds and cutting strains reduces vibrations and gives more precise product; progress in drives and speed changing; reduction in production time and simplification of maintenance.

Developments in American Machine Tool Design. Machy. (Lond.), vol. 37, no. 948, Dec. 11, 1930, pp. 339–348, 22 figs. Review of outstanding features of principal makes and types of American machine tools with data on feeds and speeds and power requirement.

Developments in British Machine Tool Design. Machy. (Lond.), vol. 37, no. 948, Dec. 11, 1930, pp. 321–338, 39 figs. Survey of trends in machine-tool design consisting of description of outstanding features of principal makes and types of machine tools with data on output, feeds and speeds, power requirements and principal dimensions; multiple turning, drilling, and milling equipment.

Developments in German Machine Tool Design. Machy. (Lond.), vol. 37, no. 948, Dec. 11, 1930, pp. 349–354, 11 figs. Review of outstanding features of principal makes and types of German machine tools with data on feeds and speeds and power requirements.

MACHINERY

Obsolescence of. Obsolescence and Organization, F. L. Watson. Engineer (Lond.), vol. 150, no. 3911, Dec. 26, 1930, pp. 710–711; see editorial comment on p. 709. A machine becomes obsolete when a new one is produced which will do same work at lower total cost; when product of machine is displaced in market by another product for which machine is unsuitable; when user makes improvement in product for which machine is not adaptable; existence of obsolete shop is injurious to whole industry; disposal of obsolete plant. Address before Instn. Mech. Engrs., Dec. 12, 1930.

MAGNESIUM ALLOYS

Castings. Magnesium Alloy Castings, E. Player. Metallurgia (Manchester), vol. 3, no. 14, Dec. 1930, pp. 46 and 52, 3 figs. Characteristics of magnesium alloys and some of principles involved in production of sound castings; strength figures and mass-strength ratio of elektron magnesium alloys, compared with other metals in common use; alloy composition; melting; molding; machining. Read before Inst. of Metals and Inst. of British Foundrymen.

MALLEABLE-IRON CASTINGS

Nickel Effect. The Effects of Nickel Upon the Mechanical Properties and Micro-Structure of Whiteheart Malleable Cast Iron, J. V. Murray. Staffordshire Iron and Steel Inst.—Proc. (Stourbridge), vol. 45, 1929–1930, pp. 40–44, 6 figs. on supp. plates. Experiments on effect of addition of nickel to whiteheart malleable iron, in both cupola and crucible-cast metal; both cupola and crucible series show best all-round properties when they contain 1.00 per cent of nickel; tensile strength increases further as nickel is raised up to limit where graphite makes its appearance; this increased strength is accompanied by refining of pearlite, especially at core, and more homogeneous structure.

MATERIALS

Elastic Deformation. Elastic Deformation According to the Theory of Plasticity (Berucksichtigung der elastischen Formaenderung in der Plastizitaetstheorie), A. Reuss. Zeit. fuer Angewandte Mathematik und Mechanik (Berlin), vol. 10, no. 3, May-June, 1930, pp. 266–274, 3 figs. Present status of theory of plasticity; foundations of theory of plastically elastic deformation, with special reference to constant speed of deformation; examples and special cases.

Optical Analysis of. Optical Method for Determination of Materials in Mixtures, Residues, etc. (Ueber eine optische Methode zur Erkennung von Stoffen in Gemischen, Rueckstaenden usw.), H. Wagner. Zeit. fuer Angewandte Chemie (Berlin), vol. 43, no. 31, Aug. 2, 1930, pp. 686–687; see also brief translated abstract in Am. Ceramic Soc.—Jl., vol. 13, no 12, Dec. 1930, p. 1100. Material to be identified as placed in special liquid of same index of refraction on microscope slide; when held in light there is noticeable a definite characteristic color; list of materials which may be identified is given, together with liquids to be used and characteristic colors obtained.

Strength of. Durability, Notch Effect, and Design (Dauerfestigkeit, Kerbwirkung und Konstruktion), A. Thum. Automobiltechnische Zeit. (Berlin), vol. 33, nos. 34 and 35, Dec. 10 and 20, 1930, pp. 818–821 and 852–854, 6 figs. Dec. 10: General aspect of stress distribution and notch effect in design of machine element; sketches and graphs illustrate notch effect as function of depth of notch and rounding of corner for different methods of stressing; notch effect factor for various materials. Dec. 20: Tables give data on vibration strength of cast iron with various surfaces; comparison of strength properties of steel and cast iron; factors determining permissible stresses; effect of over stressing.

Synthetic. The Realm of Synthesis (Synthesens Rike), E. E. Slossons. Teknisk Tidskrift (Stockholm), vol. 60, nos. 51 and 52, Dec. 20, 1930, pp. 714–718, and Dec. 27, 1930, pp. 726–730. History and development of discoveries and inventions in realm of synthesis; raw materials for synthetic products are supplied mainly from water, air, coal, and wood; influence of introduction of synthetic products and probable direction of future developments.

MATERIALS HANDLING

Bulk, Feed Control in. Feed Control in Bulk Handling, G. R. Best. Indus. Eng., vol. 88, no. 12, Dec. 1930, pp. 595–598, 5 figs. Examples of various devices used for feeder drives including individual electric motors and feeders driven mechanically by machine to which material is being fed.

MEASURING INSTRUMENTS

Errors in. Fundamental Definitions in Measuring Technique (Grundlegende Begriffsbestimmungen in der Messtechnik), V. Happach Werkstattstechnik (Berlin), vol. 24, no. 22, Nov. 15, 1930, pp. 610–612. Definition of principal kinds of errors and formulas for calculation; interpretation of terms, such as sensitivity, accuracy, and corrections, by mathematical expressions.

METALS

Bimetals—Testing. Bimetal—Its Function and Application, W. J. P. Rohn. Metallurgia (Manchester), vol. 3, nos. 13 and 14, Nov. 1930, pp. 17–19 and 25, Dec., pp. 59–61, 11 figs. Nov.: Bimetal defined as strips made from two metallic layers with different coefficients of thermal expansion; principle of bimetal strips; coefficient of thermal expansion of metals and alloys; discussion of points of view for selecting components. Dec.: Deflection curves of different bimetal combinations; instruments for testing bimetals; technical aspects of manufacture and application of bimetals.

Brittle Fracture. Brittle Fracture in Metals, B. H. Haigh. Engineering (Lond.), vol. 130, nos. 3385, 3386, Nov. 28 and Dec. 5, 1930, pp. 685–687 and 717–719, 19 figs. Nov. 28; Types of brittle fracture are illustrated and explained; brittle fractures are not necessarily indication of brittle material, but often due to manner in which material is loaded: they are also caused by fatigue; another troublesome type of failure, due to triple tension, is met with in nickel-chrome alloys. Dec. 5: In General, two distinct types of failure are possible; metal might part either by slipping or might separate normally; slipping is characteristic of ductile fracture; in brittle fractures, cracking, separation, or rupture occurs; case of simple tensile fracture; most satisfactory of all tests for brittleness is notched-bar test. Abstracts of two lectures at King's College.

Cutting. Application of Autogenous Cutting for Finished Products (Ueber das autogene Schneiden von Baustaehlen und legierten Staehlen), E. Wiss. Acetylen in Wissenschaft und Industrie (Halle), vol. 33, nos. 7, 8, and 9, July 1930, pp. 101–109, Aug. 1930, pp. 115–124, and Sept. 1930, pp. 135–141, 41 figs. July: Analysis of steels, especially those with higher carbon content; alloy steels. Aug.: Physico-technical properties of autogenously cut sections. Sept.: Machinability; results of investigation of structural and alloy steels with tensile strength exceeding 50 kg. per sq. mm.

Machinability. The Problem of Machinability Measurement, E. G. Herbert. Metallurgia (Manchester), vol. 2, nos. 11 and 12, vol. 3, no. 13, Sept. 1930, pp. 169–171 and (editorial) p. 167, Oct., pp. 206–208, and Nov., pp. 13–15, 10 figs. Sept.: Scale of machinability analogous to scales of hardness and tensile strength would assist choice of materials for specific purposes; determination by measurement. Oct.: Anomalies of direct measurement; study of cutting action; work-hardening capacity; hardness induced by cutting tools; Nov.: Law of machinability; hardness of the chip as a measure.

Plasticity. Deformation and Strength of Materials (Werkstoffverformung und Festigkeit), E. Schmid. Physikalische Zeit. (Leipzig), vol. 31, no. 20, Oct. 15, 1930, pp. 892–896, 10 figs. Report on experimental work for attempted explanation of plasticity of metals through properties of crystals; properties of single metallic crystals; comparative discussion of mechanical behavior of single crystals and of multi-crystalline structures.

Testing. Non-Destructive Testing of Metals; Present and Future, A. St. John. Iron Age, vol. 127, no. 1, Jan. 1, 1931, pp. 54–55, 1 fig. Developments in non-destructive tests are along two distinct lines; distinguishing between normal and abnormal material; with particular regard to application of X-rays.

N

NITRIDATION

Properties. Nitrided Steel and Its Properties, J. H. Higgins. Heat, Treating, and Forging, vol. 16, no. 12, Dec. 1930, pp. 1527–1529. Review of important points concerning production, heat treatment, and use; steel selection; forging; machining; quenching and tempering; decarburization; corrosion; welding; effect of heat on case; renitriding. Paper delivered before Am. Soc. Steel Testing.

Status of. Nitriding: Its Present and Future Status, V. O. Homerberg. Iron Age, vol. 127, no. 1, Jan. 1, 1931, p. 52. Development of nitriding processes including investigations conducted at laboratory of Nitralloy Corp.; gray cast iron that can be nitrided to give satisfactory case; nitriding in presence of carburizing agent; protective agents against nitriding; effect of pressure; role played by hydrogen; X-ray studies.

O

OIL ENGINES

CAS. CAS Oil Engine (Der CAS-Rohoelmotor), K. F. Naegele. Automobiltechnische Zeit. (Berlin), vol. 33, no. 35, Dec. 20, 1930, pp. 848–850, 7 figs. Design and performance test of experimental oil engine with crank-case compression in which piston controls, admission of fuel from carburetor; engine develops 3½ hp. at 2000 r.p.m. and has fuel consumption of 320 gr. per hp-hr.; ore and stroke 57 by 80 mm., and compression ratio 6.7.

OPEN-HEARTH FURNACES

Design. Development in Open-Hearth Furnace Design. Iron and Coal Trades Rev. (Lond.), vol. 121, no. 3271, Nov. 7, 1930, pp. 683–685, 5 figs. Review of features in develop-

ment of open-hearth furnace construction and design during last 10 years; increase in rate of production per hour of units employed; venturi design of port; Naismith sloping back-wall; installation of venturi furnace at Trafford Park Works of Taylor Bros. and Co. Ltd.

New Open Hearth Furnaces (Neue Siemens-Martin-Oefen), H. Illies. Feuerungstechnik (Leipzig), vol. 18, no. 23–24, Dec. 15, 1930, pp. 229–233, 5 figs. Insulation of open-hearth furnaces; larger capacity; advantages of tilting furnaces; 100-ton furnace of Laclede Steel Co.; 135-ton McKune furnace; new design of Maerz furnace; Lachner furnace; modern checkerbrick construction; electric flue-gas treatment; 200-ton tilting furnace for Talbot process.

OXYGEN

Liquid, Properties of. Properties of Oxygen at Low Temperatures (Die Zustandsgroessen des Sauerstoffs bei tiefen Temperaturen), F. Schmidt. V.D.I. Zeit. (Berlin), vol. 74, no. 50, Dec. 13, 1930, p. 1710. Physical properties and characteristics including boiling point at minus 182.8 deg. cent., melting point at minus 218.4 deg. cent. and critical temperature at minus 118.8 cent.; data on specific heat and entropy diagram. Abstract from V.D.I. Forschungsarbeiten, vol. 339.

P

PLASTICITY

Nature of. Definition and Measurement of Plasticity. The C.G.S. Unit and a New Plastometer (Begriff und Messung der Plastizitaet. Die C.G.S. Einheit und ein neues Plastometer), E. Karrer. Zeit. fuer Technische Physik (Berlin), vol. 11, no. 8, 1930, pp. 326–337, 1 fig. Evolution of term plasticity and its non-uniform use in technology; nature of plasticity and methods of determining it; quantitative definition of unit of plasticity called "Pla;" detailed description of new plastometer; industrial uses of plasticity measurements; quantitative data on plasticity of such substances as chewing gum, asphalt, rubber, cheese, bread, etc. Bibliography.

POWER PLANTS

Tidal. Tidal Power in the Argentine, M. E. Piaggio. World Power (Lond.), vol. 14, no. 3, Nov. 1930, pp. 400–403, 4 figs. Estimated construction costs of projected tidal power plant in Gulf of San José; investigation of working cycle, type of turbines and their number and arrangement, and volume of intake and outlet water to balance sea level outside and inside barrage at every hour of ebb and flood.

PRESSES

Hydraulic. Giant Hydraulic Bending Press for Ship Construction. Eng. Progress (Berlin), vol. 11, no. 12, Dec. 1930, pp. 313–314, 3 figs. Press has maximum capacity of 1000 tons, and operates at highest pressure of 3500 lb. per sq. in.; distance from center of table to inner edge of housing is 7.25 ft.; table itself is 13 ft. deep and 10 ft. wide; clear distance between table and ram head is 6 ft. while total height of press is 46 ft.

PRESSURE VESSELS

Manufacture. Making High-Pressure Steel Drums in Germany. Iron Age, vol. 126, no. 4, July 24, 1930, pp. 232–233, 4 figs. Manufacture of high-pressure drums for chemical plants by August Thyssen Huette Gewerkschaft, Duesseldorf; steel is of 50,000 to 64,000 lb. per sq. in. tensile strength and heat-treated during fabrication of drum to eliminate strains; steel of 58,000 to 71,000 lb. tensile strength can be furnished; ingots of 20 to 30 tons are rolled into plates, usually 4300 mm. wide, 16 m. long, and 70 mm. thick, weighing 18 tons; from such plate, drum may be formed with inside diameter of 1250 mm. and with single longitudinal welded seam.

PULVERIZED FUEL

N.E.L.A. Report. Pulverized Fuel. Nat. Elec. Light Assn.—Pub., no. 12, Dec. 1930, 64 pp., 64 figs. Report contains statements for 1929 on pulverized fuel from 29 operating companies, covering: equipment; mills and exhausters; coal fineness, sampling methods, combustible in fly ash; driers; vent and washing methods; boiler operation; boiler outages and maintenance methods; burner and furnace performance; control; statements also included from 13 manufacturers.

Firing With. Fundamental Problems of Firing With Pulverized Fuel, L. K. Ramin. Izvestiya Teplotechnicheskovo Instituta (Moscow), no. 4, 1930, pp. 22–23. General theoretical discussion of problem, and results of experimental studies and tests made at Moscow Thermotechnical Institute, on pulverizing of moisture containing local coals and on combustion of pulverized lignites and coals; author advocates pulverization without preliminary drying and use of individual pulverizing units. (In Russian.)

PUMPS

Gear. Gear Pump Tests (Prove su di una pompa ad ingranaggi), A. Castagna. Aerotecnica (Rome), vol. 10, nos. 7–8, July-Aug. 1930, pp. 613–628, 10 figs. Set-up at Engineering School of Torino and graphical interpretation of results showing relations of pressure, revolutionary speed, and output; calculation of resistance coefficient in various parts of system.

R

RAIL MOTOR CARS

Canadian National. Self-Propelled Car Operation, Canadian National Railways. Can. Ry. and Mar. World (Toronto), no. 394, Dec. 1930, p. 767, 2 figs. Operating schedules of storage battery, gas-electric, gas-mechanical, and oil-electric cars.

Diesel-Electric. Twin Diesel Rail-Car. Diesel Power, vol. 8, no. 12, Dec. 1930, p. 621, 1 fig. Brief description of car built by Westinghouse Electric and Manufacturing Co.; maximum speed 80 m.p.h.; length 75 ft.

Hungary. Rail Motor Cars in Hungary. Locomotive (Lond.), vol. 36, no. 460, Dec. 15, 1930, pp. 416–418. Conservative method of running mixed trains, combining passenger and freight traffic; motor-bus equipment and operation; gasoline and heavy-oil engine design for rail motor cars and motor-bus power plants.

Propeller-Driven. Railways, the German "Zeppelin on Rails," J. E. Wallis, Jr. Commerce Reports, no. 50, Dec. 15, 1930, pp. 699–700. Results of operating tests and of high-speed trials; powered by 500-hp. type VI airplane engine, manufactured by Bayerische Motorenwerke; engine also drives air compressor for brakes and two generators for charging storage battery; battery furnishes current for operating auxiliary motor to be used in starting and extra source of power; vehicle is propeller driven.

The Propeller Coach. Eng. Progress (Berlin), vol. 11, no. 12, Dec. 1930, pp. 323–324, 4 figs. Brief account of results of trial with railroad car driven by propeller; total length is 85 ft., with accommodations for 50 passengers; body is streamline; 4-blade air propeller at rear is driven by 12-cylinder engine, which develops rated output of 500 hp.; engine also drives air compressor and two d.c. generators for charging storage battery, which supplies current for lighting and ventilation, and for driving electric motor, which is occasionally used to propel coach with engine at rest.

ROLLING MILLS

Pressure Measurement. Device for Measuring Pressure in Rolling Mills (Eine Vorrichtung zur Druckmessung an Walzwerken), E. Voigt and W. Lueg. Mitteilungen aus dem Kaiser-Wilhelm-Institut fuer Eisenforschung (Duesseldorf), vol. 12, no. 11, 1930, pp. 161–164, 5 figs. Electrically driven apparatus suitable for rolling mills; by means of optical or recording indicator, it is possible to measure pressures occurring during rolling.

Rolling Efficiency. Effective Work and Losses in Rolling Process (Nutzarbeit und Verlustarbeit beim Walzen), E. Seibel and A. Pomp. Mitteilungen aus dem Kaiser-Wilhelm-Institute fuer Eisenforschung (Duesseldorf), vol. 12, no. 11, 1930, pp. 149–159, 8 figs. Calculation of rolling work from rolling pressure; investigation of cold rolling mills; cold-rolling tests demonstrated high losses, which were due to bearing friction; especially unfavorable conditions were established in case of journal bearings with sight-feed lubrication, whereas journal bearings with pressure lubrication and roller bearings gave better results.

Steam Meters in. Steam-Consumption Measurements on a Heavy Rolling Mill (Dampfverbrauchs-Messungen an einer schweren Walzenstrasse), H. Weiss. Stahl und Eisen (Duesseldorf), vol. 50, no. 49, Dec. 4, 1930, pp. 1705–1708, 11 figs. Steam meters of Hallwache & Langen are described; measurements of steam consumption of separate charges in rolling of section iron, semi-finished material, rails and ties; influence of temperature of material on power consumption; as result of steam measurements, improvements in calibration of cross-sections of rolled pieces can be effected, when necessary.

ROLLS

Cast-Iron. Breakage of Rolls, F. Bacon. Foundry Trade Jl. (Lond.), vol. 43, no. 747, Dec. 11, 1930, p. 404. Abstract of paper on fatigue stresses, with special reference to breakage of rolls, presented before South Wales Inst. Engrs. at Swansea; examination of all available data as to fatigue limits and endurance ratios for cast irons; mathematical investigation of torque; curves to evaluate stress ratios corresponding to hair-crack markings on broken rolls.

S

SCREW THREADS

Measurement. New Method for Measuring Internal Threads (Ein neues Verfahren zur Messung von Innengewinden), G. Berndt and E. Bock. Zeit. fuer Instrumentenkunde (Berlin), vol. 50, nos. 6 and 7, June 1930, pp. 375–384, and July, pp. 407–416, 7 figs. Principles of measuring methods based on use of balls and prisms and Universal measuring microscope, developed by University of Dresden and Zeiss Co.; mathematical analysis of accuracy and errors; tables give instrument correction for Whitworth and metric thread.

SHEET IRON

Hot Rolling. Influence of Degree of Rolling, Rolling End Temperature, and Heat Treatment on Mechanical Properties, Sensitivity to Aging, and Structure of Thick Sheet Iron (Einfluss des Walzgrades, der Walzendtemperatur und der Waermebehandlung auf die mechanischen Eigenschaften, etc.), F. Koerber and K. Wallman. Mitteilungen aus dem Kaiser-Wilhelm-Institut fuer Eisenforschung (Duesseldorf), vol. 12, no. 13, 1930, pp. 171–191, 94 figs. partly on supp. plates. Four steels of different carbon and silicon content were rolled at 900, 800, and 700 deg. cent. to plates of 25, 20, and 15 mm. thickness and investigated to determine tensile strength, yield limit, elasticity, shrinkage, elongation, and notch toughness.

Testing. Influence of Shape of Specimen on Notch Toughness of Thick Sheet Iron of Different Composition and Heat Treatment (Einfluss der Probenform auf die Kerbzaehigkeit von Grobblechen) ver schiedener Zusammensetzung und Waermebehandlung, F. Korber and K. Wallmann. Mitteilungen aus dem Kaiser-Wilhelm-Institut fuer Eisenforschung (Duesseldorf), vol. 12, no. 13, 1930, pp. 193–202, 7 figs.; see also Stahl und Eisen (Duesseldorf), vol. 50, no. 49, Dec. 4, 1930, p. 1724. Notch hardness of different rolled and annealed and heat-treated plates, measured on three forms of test pieces; comparison of results.

SPRINGS

Materials for—Testing. Simple Arrangement for Determining Spring Quality of Spring Strip Material (Sonderlehre zum Pruefen der Lagerschalen von Pleuelstangen), P. Grodzinski. Maschinenbau (Berlin), vol. 9, no. 24, Dec. 18, 1930, p. 809, 3 figs. Design of simple test fixture together with tables containing results for principal spring materials.

STANDARDIZATION

Development of. Standardization, W. Sisson. Instn. Mech. Engrs.—Proc. (Lond.), no. 3, 1930, pp. 787–792. Meaning of standardization and development of constituent standards dealing with composition and physical properties of materials to be used; dimensional standards dealing with size and shape of unit parts, or elements of construction; collective or correlative standards dealing with relationship of unit parts in combination, and individual standards dealing with combination or assembly of parts.

STEAM ACCUMULATORS

Systems. Steam Accumulator Systems, F. J. Matthews. Colliery Eng. (Lond.), vol. 7, no. 79, Sept. 1930, pp. 327–329, 3 figs. General notes on accumulators; principles involved; two types of systems, exemplified by Ruths and Kiesselbach accumulators; size of accumulator; types of commercial accumulators; advantages of steam accumulators.

STEAM-ELECTRIC POWER PLANTS

Design. Engineering Developments in the Power Industry During 1930. Power Plant Eng., vol. 34, no. 24, Dec. 15, 1930, pp. 1387–1389, 3 figs. Résumé of principal power-plant developments of year based on analysis of equipment installed in 25 selected stations throughout